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Putting Responsibility Up to Each Department

By Fred H. Colvin
Editor, *American Machinist*

A method of management whereby each manufacturing department is run as a separate shop that sells its product to the assembling department for final sale

THE articles that have appeared in the *American Machinist* under the title, "Getting the Most Out of Your Machine Tool Dollar" have pointed out very clearly the many problems that confront the manufacturer whose product can be produced for the most part with standard machine tools. The points to be considered in selecting new equipment and in discarding the old have been made clear and the methods given must have been of great value to those whose problem is the proper selection of machines already on the market.

There are, however, manufacturers whose products require machinery that cannot be bought in the open market, but that must be built specially for the work to be done, either by the manufacturer or to his order. The only standard machine tools he buys are used in the building of his special machinery. And while he must have a good machine tool equipment for this purpose, its use is a job shop proposition and not manufacturing in any sense.

An example of this manufacturing with special equipment is in the making of incandescent electric lamp bulbs, the Westinghouse Lamp Co. plant at Bloomfield, N. J., giving a good idea of such an establishment. Practically speaking, every machine in the manufacturing departments is of special design for the work to be done and cannot be purchased anywhere. As a result the machines have no second-hand value beyond the price of scrap when they are thrown out to give way to newer equipment.

There are a number of unique features about this plant that make it of special interest both as a problem in manufacture and in management. And in spite of the very ingenious machinery that has been devised and built, the management phase of this plant is of at least equal interest.

Each branch or division of the plant is in reality a separate shop although housed in the same buildings. The divisions that make the filament and lead-in wires, the brass bases, the glass tubes and other parts, are

Fig. 1—Section of machine shop with new machines

Fig. 2—One of the glass-working departments

as separate as though they belonged to different companies.

The Development and Engineering Division, for example, employs approximately 600 people and is absolutely independent of the rest of the plant. It has its own staff, its own space and even its own bank account and payroll. It pays rent for the space occupied and the power used.

The development end of this division is, of course,

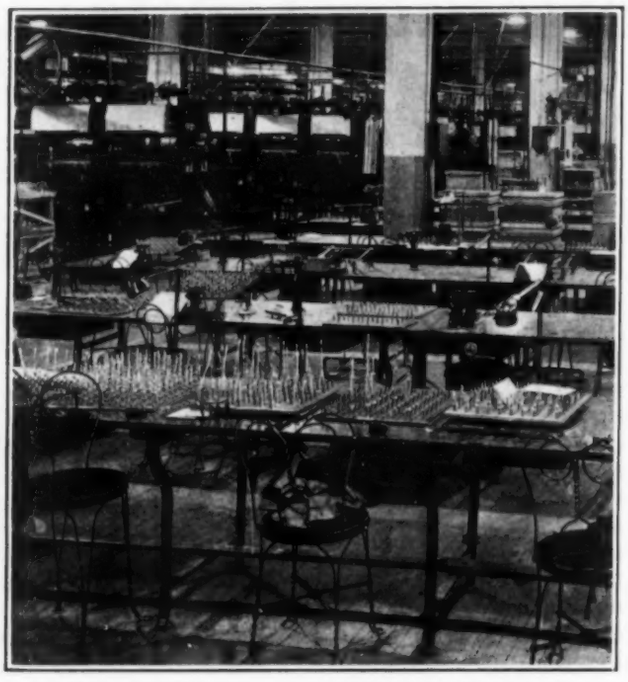


Fig. 3—A lamp manufacturing department

eternally at work on new designs for better and more economical machinery to be used by the manufacturing divisions. When a new idea for a machine or a process is evolved and put into explainable form, it is "sold," if possible, to the manufacturing division. The cost is figured so as to show a profit to the development and engineering division. If the cost is considered too high to allow a profit for the manufacturing division for which it is intended, this division refuses to buy it just as the user of a machine tool must see a profit before purchasing.

The method of lamp manufacture is changing so rapidly that new equipment is constantly in demand, and there is rarely any danger that new machinery, considered by development engineers to be an improvement, will be rejected by the manufacturing divisions. The rapidity of these changes can be appreciated by considering that the actual life of the machines seldom exceeds four years and that a 3-year life is usual.

Unlike machine tools in the automotive shops, these machines are bought on a basis of paying for themselves in three years and are scrapped after from three to four years of service. Instances are cited of where a battery of new machines was scrapped before being installed because a newer and far superior method had been developed before the machines were completed.

It is self-evident that an appreciable time must elapse between the designing of a new machine and the actual building of a lot for the production divisions. For not only must the machine be designed but the bugs must be eliminated and the machines built before they can go into production. While this is going on, a newer and much better method may be in its embryo stage in the process of development. But knowing the time that must elapse before the latest idea can be put into the manufacturing divisions in the shape of completed machines, it is frequently an economy to build the machines that improve the methods *now* in use, even though it is known they will be obsolete in two or three years at the most. And it must be remembered that the machines that are replaced have nothing but a scrap value when they are discarded.

It takes an executive with broad vision, rather than nerve, to handle problems of this kind. And it might seem as though the desire for change would lead to the discarding of a process before it had outlived its real usefulness. But the fact that the selling price of incandescent lamp bulbs is constantly being lowered, and that they are now sold at a figure that would have been incredible a few years ago, seems to prove the wisdom of the replacement policy in effect.

The separate shop idea is carried to such an extent that one division may refuse to buy its parts from another division if the price asked is too high. If, for example, the manager of the assembling division finds that he can buy his wire, or bases, for less money from another maker, he promptly refuses to pay more than the market price for this part. And he is at liberty to purchase elsewhere if the supplying division cannot meet the price of a competitor.

It seldom happens, however, that this condition obtains, as the supplying division immediately gets busy and finds a way of reducing its costs, or its profits, or both, so as to meet the competitive price. With each division subject to such constant scrutiny as to costs, there is little chance of its falling far behind in its methods. Any division can, of course, call on the development engineers to help reduce the costs, and the ideas of the men in each division are earnestly sought and considered.

The development division is one of the keynotes of the whole organization and the question of personnel

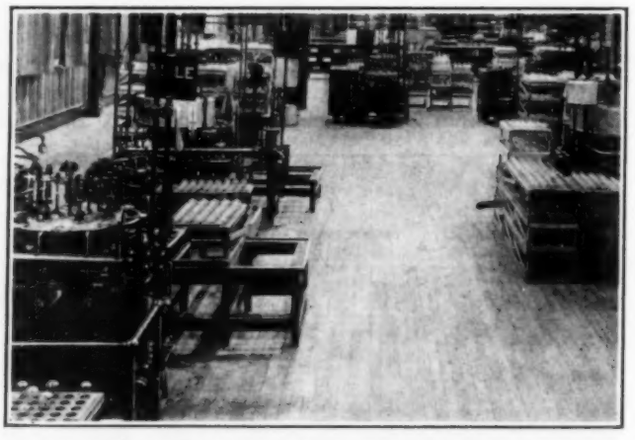


Fig. 4—Two of the special machines

is highly important. Men have to be trained, not only in the designing and engineering ends of this division, but in the building of the special machines as well. With this need in mind, the division has in the neighborhood of 25 young men in training at all times and out of the 600 people on its payroll over 100 have had the special training of this course, which is under a well-paid instructor.

It is interesting to note that 84 per cent of the young men trained in this way are still with the division.

Here is a case where the idea of sending a boy out to work in other shops does not seem to fit. There are very few shops where he would get experience that would be particularly helpful in lamp manufacture. Then, too, he would lose many opportunities for advancement in a business that is constantly expanding at a rate equivalent to doubling about every five years. Such a growth offers chances for getting ahead that are not to be lightly treated.

One of the notable features of this organization is the way in which it utilizes the shutdown or vacation period for relocating machinery in the different departments. Some changes are, of course, necessary at almost any time, but the time for rearranging departments for the introduction of new methods and new machinery is usually during the vacation period of two weeks, while the plant is idle.

Plans are made for the new arrangement and blueprints are prepared showing every machine in its new location. The work is scheduled so that it can be seen just how the change is progressing. Each day should show the changes that have been scheduled for that date. In order to follow this, the blueprint diagram of each machine is done over in yellow when it is in place. By this means a glance at the diagram shows just what has been accomplished and how much remains to be done.

In some instances these changes are so great that it is only by the skill and experience of the millwrighting department, and the hearty co-operation of all hands, to the extent of working nights and Sundays if need be, that they can be made in the required time. One change that has recently been made involved the combining of two departments and the forming of a new one. The floor space occupied was 80x450 ft. and the work involved moving one department to another floor and rearranging the machinery, as well as installing a large number of new machines that had been built for the work. The old machines were all moved to their new location and the new ones installed with them in four weeks' time.

Ready for Production

In addition to merely installing the machines, it is also necessary to put them into operation, both for the purpose of testing out the new equipment and for training the operators before the new arrangement and equipment are turned over to the production department. Any adjusting that may be necessary must be done before the machines are started on their regular work, for once on a production schedule they must be in shape to run at their maximum output.

Returning once more to the question of the independent management of each division, it is easy to see how such a system develops a type of manager who is of great value to any organization. Being responsible for the profitable management of his division means far more than being able to get out a specified number of parts at a given cost. Each division manager must keep tabs on the condition of the market of the materials he uses as well as the probable outlet for lamps after they are made.

It occasionally happens that a division manager sees an opportunity to reduce his costs by installing new machinery that has been developed. But, like many other manufacturers, he may not have a sufficient bank balance to pay for them. In such a case he goes to the general superintendent and explains the situation. He must be confident that the investment will prove profitable in three years. He must realize that the profits of his department may be cut the first year on account of repaying the loan, with interest. But if he is confident that it will pay within three years and can convince the general superintendent, he gets the money.

Men trained in this way become unusually valuable to themselves and to the firm, and when the spirit of co-operation is encouraged, as in this case, the result is a harmonious, loyal and enthusiastic corporation that can, and does, accomplish great results.

Welding Reduced the Junk Pile—Discussion

By E. Andrews
Manchester, England

I read with interest the abstract under the title given above, and published on page 989, vol. 63, of the *American Machinist*, because I have had considerable experience in reducing the metal scrap piles in our railroad works during the past few years by modern welding methods. Not only are the ferrous metal scrap articles reclaimed, but also the non-ferrous metal scrap. In fact there are comparatively few metal parts of a passenger railroad car, or of a motor vehicle, that cannot be salvaged from the scrap pile, when broken or worn, by the oxy-acetylene torch flame or electric arc. In our works by autogenous welding we are utilizing scrap material wherever possible, reclaiming broken and worn parts of machinery, locomotives, passenger and freight cars, and motor transport vehicles.

Each process has its particular advantages, although cutting is wholly confined to the oxy-acetylene torch. The principal advantage of electric arc welding is that it confines the heat to a small area, thus reducing the expansion or contraction. It is also not necessary to preheat wrought iron or steel when using the arc.

The importance of making the proper preparation for a weld cannot be over-emphasized. Any time spent in preparing adequately the work before the weld is attempted is amply repaid afterwards in the easier execution made possible by it, and also by the homogeneous nature of the weld. Metal that is clean is much more likely to make a good strong weld than when impurities are present. Beveling the edges is generally necessary for materials ⅛ inch in thickness and upwards. For copper we use a welding rod of phosphor-copper with just a trace of aluminum, or very pure copper deoxidized with a trace of phosphorus. An aluminum alloy welding rod is used where fractured parts are of aluminum alloy, and for wrought iron and mild steel the welding rod should be of soft pure iron. For cast iron, the welding rod may be of the best gray cast iron, with about 5 per cent silicon, also tobin bronze, or a bronze containing manganese. There is less brittleness and more elasticity with these bronzes than with the cast iron welding rod. Tin and iron may be employed advantageously on cast and malleable iron.

We use the electric arc, and have had very good success for building on frames and lugs on air brake cylinders, for welding in flues, for repairing fractured steel and steel alloy articles, and for work where there is liability of distortion if welded by the oxy-acetylene torch. There is no end to the economies, both in time and materials, that can be accomplished by employing modern electric and autogenous welding methods.

Book Reviews

Metric System. Compiled by Julia E. Johnson. Number 8, Vol. 3, in The Reference Shelf. One hundred eleven pages, 5x7¼ in. Cloth boards. Published by the H. W. Wilson Company, New York City, price 90 cents.

An invaluable little book for manufacturers or others likely to be affected by a possible adoption of the metric system in this country. In the first part of the book the compiler has made separate briefs of the principal arguments given by authorities for and against the system, conveniently arranged for ready reference. A synopsis of the system by the Bureau of Standards is included, followed by reprints of short arguments in favor of, and against, the system, written by leading authorities. No attempt has been made to take either side, and the book should be valuable to all who desire to acquaint themselves with both sides of the case.

The American Year Book, Edited by Albert Bushnell Hart, and William Schuyler. Eleven hundred fifty-eight pages, 5x8 in. Cloth. Indexed. Published by the Macmillan Company, New York. Price $7.50.

For the first time in six years this annual has appeared with a more elaborate program and with about 35 per cent more material. The book is sponsored by The American Yearbook Corporation, which is composed of representatives of fifty learned societies authorized to carry on the work. The new volume covers events and progress in 1925, written by 270 men and women eminent in their respective fields. The book is divided into eight parts and 360 sections, covering History, Government, Economics, Business, Social Conditions, Science, the Humanities, and Necrology.

Forecasting, Planning and Budgeting in Business Management. By Percival White. Two hundred and sixty-seven pages, 5½x8¼ in. Illustrated by charts and diagrams. Published by McGraw-Hill Book Co., Inc. New York. Price $2.50.

As the title indicates, Mr. White has divided his book into three sections dealing with forecasting, planning and budgeting, respectively. The various topics are treated simply enough so that the book can be used to good purpose as a textbook. At the same time it should be useful as a reference book or manual to many an executive whose early education in these phases of modern business has been neglected.

A valuable feature of the section on forecasting is an explanation of the basic principles on which the more important of the current services in this field are established. This leads naturally to a chapter on the business cycle and its application to the needs of the individual. Then follows considerable material on the analysis and presentation of data. The theory of index numbers is explained.

Planning and budgeting are carried along more or less together during the remaining chapters in which their application to the financial, sales, purchasing and production departments is explained. The final chapter, on management, serves to tie the whole discussion together and show how the three functions under discussion are co-ordinated.

Lectures on Engineering Practice, 1924-1925. Published by the School of Engineering, Johns Hopkins University, Baltimore, Md. This book contains in bound form four lectures on engineering practice, made at the university. The titles of the lectures are: "Present Aspects of Coal Carbonization," by C. J. Ramsburg, vice-president of the Koppers Co., Pittsburgh, Pa.; "Distribution of Gas," by Alfred Hurlburt, vice-president of the Equitable Gas Co., Pittsburgh, Pa.; "The Utilization of Gas," by Henry O. Loebell, vice-president and general manager of the Combustion Utilities Corporation; and "The Low-Temperature Carbonization of Coal," by A. C. Fieldner, superintendent and supervising chemist of the Pittsburgh Experiment Station, U. S. Bureau of Mines.

The Merchants' Association of New York, Year Book, 1925. Three hundred sixty-six 7x10-in. pages. Published by the Merchants' Association of New York, 233 Broadway, New York, N. Y. This book constitutes a record of the activities of the various bureaus of the association and a directory of the members. The activities of the bureaus were numerous and full reports are given on such topics as traffic, foreign trade, industry and legislation. Because of its size the directory of members forms a valuable guide to the business establishments in New York. Following the alphabetical list is a classified directory with an index to the classifications.

Foreign Commerce Handbook, 1926-1927. Thirty-six, 6x9-in. pages. Published by the Foreign Commerce Department, Chamber of Commerce of the United States, Washington, D. C. This booklet contains the sources of information available on questions relating to foreign trade. The sources are listed under alphabetically arranged headings. It is the aim of the handbook not only to serve as an indication of where export and import service in the United States may be had but also to show some of the activities of the committee. A list of foreign trade matters on the program of the Chamber of Commerce is appended in brief form to the booklet.

Union Scale of Wages and Hours of Labor, May 15, 1924. Published by the Department of Labor, Washington, D. C. Bulletin No. 388 of the Bureau of Labor Statistics. Price 25c. This bulletin gives the average hourly rates of wages and the number of changes in union scales in specified trades in the United States, the weekly hours of labor in the principal trades as well as a comparison with those of each year, beginning 1907. A table gives the union scale of wages and hours of labor in specified trades, May 15, 1924, and May 15, 1923, by cities, this table occupying the greater part of the book.

Erratum

In the review of "The Locomotive," published on page 442, Vol. 64 of *American Machinist*, the price of this volume was given as $3. This was an error. The price of the book is one dollar.

Modern Tooling Methods for Turret Lathes

By M. E. Lange
Production Engineer, The Warner & Swasey Co.

The answer to what the production executive wants to know about the most efficient tooling for both small- and quantity-lot production

WHEN the production executive is considering improvements in tooling, the final question asked is: "Will the increased production pay for the cost of the equipment, and also give a substantial profit on the investment?"

The experienced manager recognizes the advantages of better methods, but he knows the conditions are often changing from day to day in his shop, and that many times apparently well-planned improvements fail to produce the expected results. Moreover, the money available for such improvements is often limited and before authorizing any expenditure the production executive wants to know:

1. What average saving the new equipment will make over a period of time, under the exact conditions in his shop.
2. What the proposed tooling equipment will cost.

The great difference in the quantity of work produced in a lot in the different shops, immediately suggests one answer for the small- and average-lot producers, and another for the quantity producers. Let us first consider the average shops where work is produced in small or average lots of from five to one hundred pieces.

The answer for the small-lot producer.—In order to obtain the answer for the average shop where the production is in lots of from five to one hundred pieces, let us compare the production and cost of a typical home-made set of chucking tools and a universal equipment.

The set of chucking equipment shown in Figs. 216 and 217 is typical of well developed shop-made tools designed by the foreman. It will handle a fairly wide variety of work and permits the use of combined cuts. However, this home-made set will not give multiple cuts from the turning heads, and is not very rigid. Fig. 219 shows a cast-iron spider hub, a typical chucking piece, similar to the majority of the pieces illustrated in the articles on chucking work.

The machine tooled for producing the spider hub with shop-made equipment, is shown in Fig. 216, and the tooling layout is given in Fig. 217. The same job is shown in Fig. 218 on the same turret lathe, equipped with a standard, universal set of overhead-piloted tools, the tooling layout being shown in Fig. 220. The two standard multiple-turning heads will hold boring cutters in the center holes, as well as several angle cutter holders. In this way, multiple cuts may be obtained from each tool.

The concluding article.

The difference between the home-made and standard tool is shown in Figs. 221 and 222. The positive support of the overhead-piloted bar gives rigidity for heavy feeds. The set-up time for the universal equipment is even less than for the original equipment, because of the definite provision made for positive adjustment of cutters in the tools.

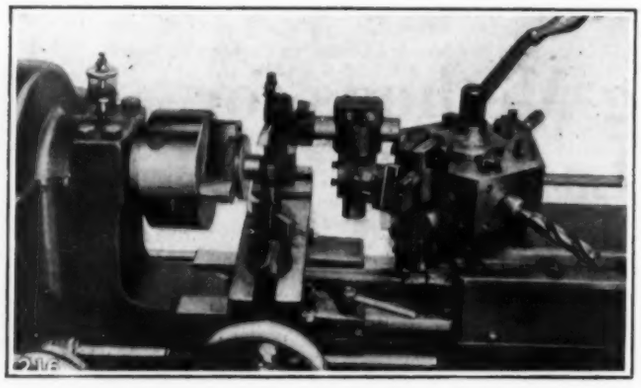
A comparison of the operations necessary to produce the spider hub with the original equipment and with the universal tooling-equipment is given in the accompanying table, and emphasizes the increase in production commonly gained from the better method.

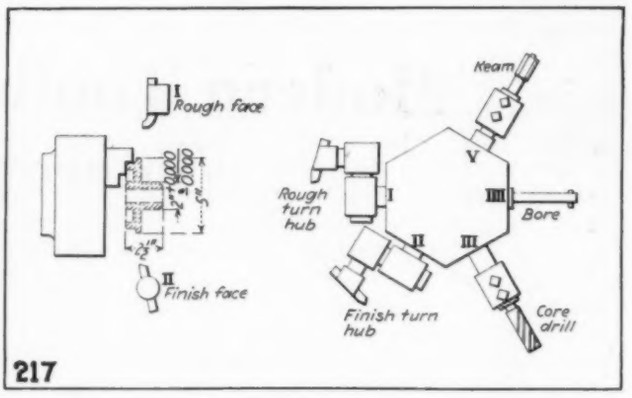
Comparison of Operations

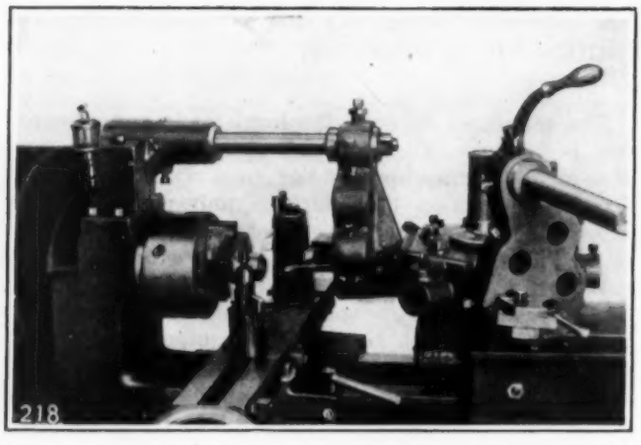
Operations with original equipment	Operations with universal equipment
I. Rough turn hub with homemade turner. At same time rough face the flange with cutter on rear of cross slide.	I. Rough turn hub and bore with turning head from hexagon turret. At same time rough face the flange with cutter from front of cross slide.
Feed—0.008 in. per revolution of spindle.	Feed—0.013 in. per revolution of spindle.
II. Finish turn hub. Finish face flange.	II. Finish turn hub. Bore hole. Finish face flange.
III. Rough drill the hole.	III. Ream the hole.
IV. Finish bore the hole.	
V. Ream the hole with reamer.	
Production time— 10 minutes.	Production time—7 minutes.

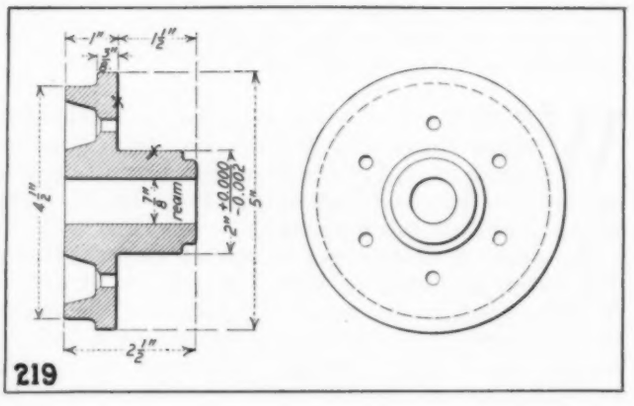
Thus on even a simple job of this sort the operations are cut from five to three. The feed for the roughing cut is increased from 0.008 in. per revolution with the home-made tools to 0.013 in. with the universal equipment because of the piloting. The production time per piece is reduced from 10 to 7 min. The set-up time, which is a very important factor in small lot production, is about the same for both methods, and on many other types of work will be found to be even less because of the permanent set-up. Fig. 223 shows the wide variety of work handled by the universal set.

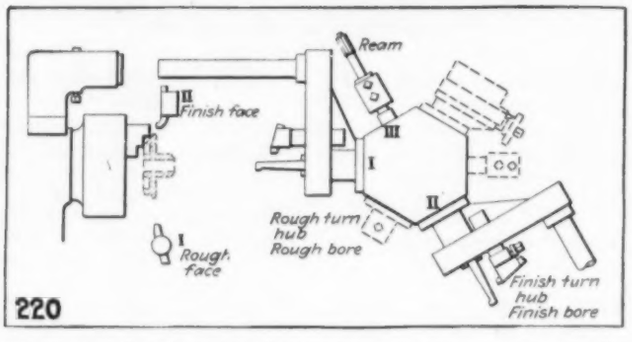
The example of the tooling for an adjusting sleeve, Fig. 224, was suggested by the foreman of the shop involved, as a conservative example of the savings realized through the use of universal tooling-equipment for small- and average-lot work. Let us reduce to definite

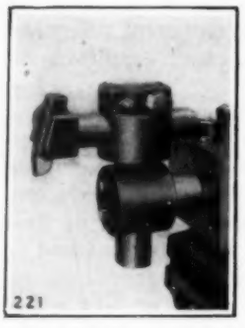












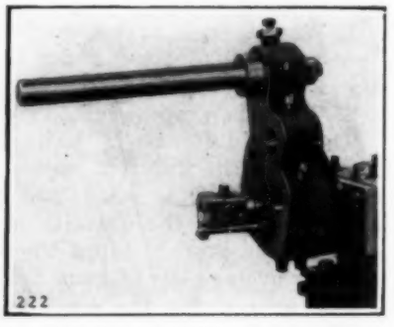


Fig. 216—Machine tooled for producing a spider hub by the old method. Fig. 217—Tooling layout of old method. Fig. 218—Machine tooled for producing a spider hub by the new method. Fig. 219—The spider hub. Fig. 220—Tooling layout of new method. Figs. 221 and 222—Home-made and standard tools

figures the value of the increase in production in this shop, as compared with the exact cost of the tools.

I. The average saving in production time with the universal tooling-equipment in this shop is 30 per cent. While different shops will always use different rates, let us assume an average basis and figure the saving in dollars and cents.

With 60c. for labor, and 90c. for factory overhead, or $1.50 per hour, the charges for one machine per 8-hour day are 8 × $1.50 = $12.

The average saving with this equipment is 30 per cent of $12, or $3.60.

II. The exact cost of the equipment is $307. It will therefore take the following time to pay for itself:

$$\frac{\$307 \text{ (cost of equipment)}}{\$3.60 \text{ (saving per day)}} = 85 \text{ days of full-time operation.}$$

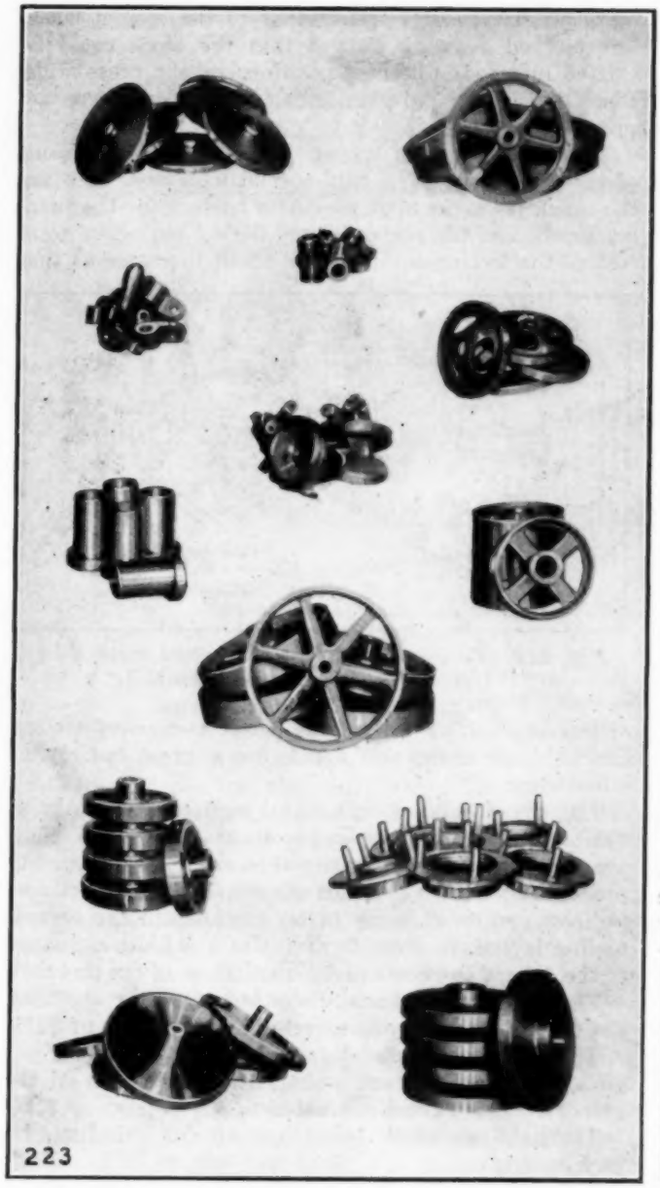
After the equipment is paid for in 85 days, the investment will earn:

$$\frac{\$3.60 \text{ (saving per day)} \times 280 \text{ (days per year)}, \text{ or } \$1,008}{\$307 \text{ (cost of equipment)}} = 328 \text{ per cent per year.}$$

The answer to the final question of the production executive may then be given as follows:

For small- and average-lot production, a set of universal tooling-equipment will cut production time from 15 to 40 per cent. The cost of either bar or chucking equipment for 16- to 18-in. machines, will vary from 15 to 22 per cent of the value of the machines. The increased production will pay for the new tooling equipment in from two to six months, and after that will give an annual net profit of from 150 to 400 per cent.

The answer for the quantity producer.—The real problem of the quantity producer is to increase production with tooling equipment that can be used for a long period of time, in spite of changes in the production. The greatest advantage of universal tooling-equipment for the quantity producer, lies in the flexi-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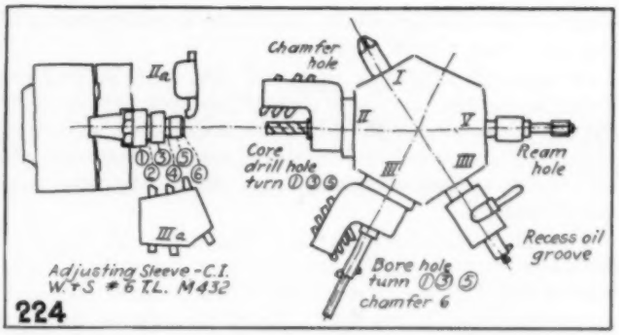
Chamfer hole
Core drill hole turn 1 3 5
Ream hole
Recess oil groove
Bore hole turn 1 3 5 chamfer 6
Adjusting Sleeve - C.I. W.F.S. # 6 T.L. M432
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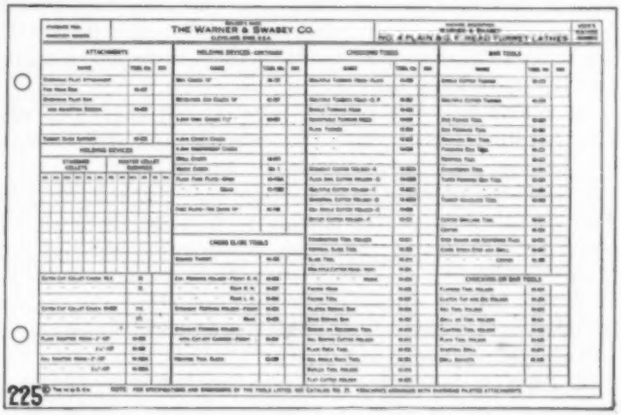
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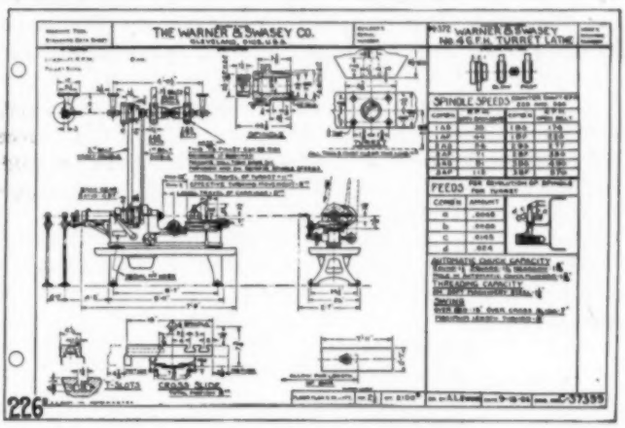

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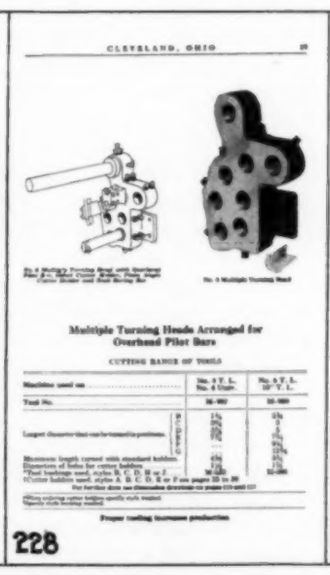

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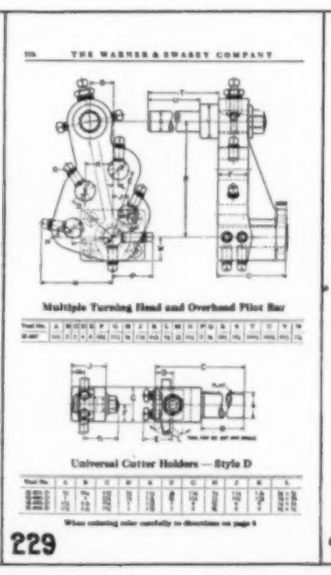

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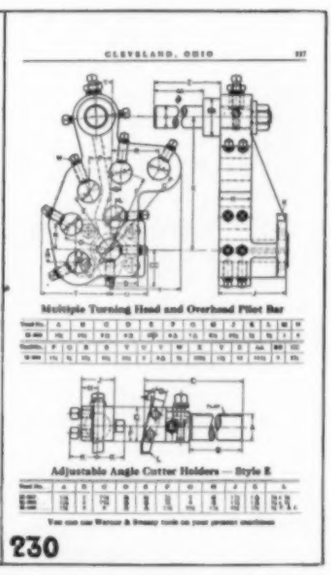

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Fig. 223—Work made by universal equipment. Fig. 224—Tooling layout for first method of producing an adjusting sleeve. Fig. 225—Complete tool inventory. Fig. 226—Machine tool data sheet. Figs. 227 to 230—Catalog pages

bility of the tooling, which results in a greatly-reduced tool cost over a period of years.

In order to illustrate how tool cost may be reduced through the application of better methods, let us compare two layouts for the same job, a cast-iron adjusting sleeve. The first method employed special tools entirely. The better method uses standard, universal tools wherever practical.

The first layout, Fig. 224, was made by the tool designer for making the piece in large quantities. Two special turning heads were provided to finish the outside diameters and the hole. The oil groove was recessed with a special eccentric tool. The necking and rough facing were done from the cross-slide with a special block, so that the only standard tools were the reamer and the rear toolpost.

In discussing this preliminary layout, the chief engineer called attention to the expense and inflexibility of the tool layout, and also to the trouble then experienced in getting concentricity with a similar job. The center hole in the sleeve was so small that the small core drill and the weak center-pilot bar did not give the rigidity necessary to support outside cuts, so that the turned diameters would not clean up on the grinder. The chief tool engineer proceeded to revise the designer's layout as follows:

I. First a brief study was made of the standard, universal tools available from the maker and suitable for the job. The complete tool inventory furnished by the maker, Fig. 225, was consulted and several tools shown in the chucking section were considered.

II. In order to solve the problem of concentricity, overhead piloting was decided upon to give the necessary rigidity. The exact tool used was decided by studying the method sketches, Figs. 227 and 228, accompanying the description of each tool. The multiple-turning head with overhead pilot was therefore finally chosen.

III. The dimension drawings in the rear of the tool catalog, Figs. 229 and 230, gave detailed dimensions of all parts of this tool, so that tool clearances were definitely checked, and combined cuts made certain.

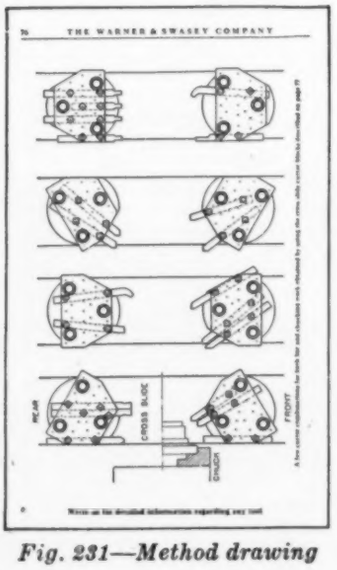


Fig. 231—Method drawing

To get four multiple cuts with one standard turning head, it was decided to make a simple, special, multiple-cutter holder. The detailed dimensions shown in the clearance section, together with the machine tool data sheet, Fig. 226, supplied by the maker, gave all the information necessary to do this without tool interference.

The use of special blocks on the cross-slide was so established in this plant, that the possibilities of universal types of tools for this purpose were overlooked in the first discussion. In a later study of turret lathe tools the catalog method-drawing shown in Fig. 231 finally suggested the use of a universal, cross-slide cutter block, at a cost equal to that of the special block. The method drawing showed that the block could be shifted into four different positions on the cross slide, hence its use on different jobs in the future was assured.

The revised tooling layout, Fig. 232, was the result of these changes. The only special tools now used are the chuck jaws, the multiple-cutter holders for the turning heads, and the center-piloted boring bar. The total cost of the tooling equipment is about the same as that

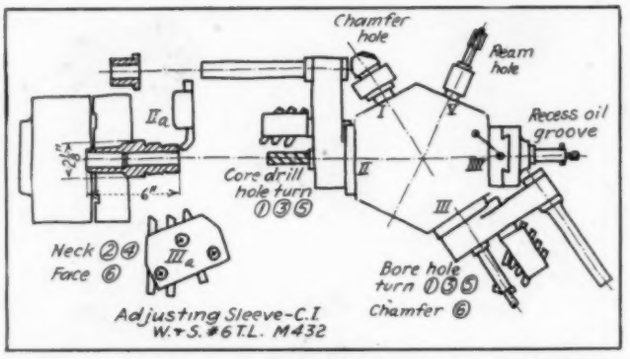


Fig. 232—Tooling layout for the better method of producing an adjusting sleeve

of the original layout, but the better method of tooling can be used again and again for a great variety of other work.

The advantages of using tool equipment that is as flexible in its application as the standard machine itself, are obvious. Before leaving this example of quantity production, however, let us summarize the direct and indirect results of using better methods in the revised tooling layout, in order to arrive at a definite summary of the dollars and cents saved, regardless of the tool cost.

Through heavier feeds, because of greater stiffness, the output per year was increased to the value of $303.

The scrap was reduced from 1,000 to 200 pieces per year, because the work would clean up better on the grinder. This saving amounted to 800 × 15c., or $120.

Through less stock being left on for grinding, 1c. each was saved on 215 pieces per day, or $2.15. With 280 days in the year, the saving amounted to 280 × $2.15, or $602.

Total saving per year in dollars, $1,025.

The cost of the standard, universal tooling-equipment was the same as that of the special tooling originally planned.

While the standard tooling has many features not necessarily demanded by this job, these features make the tooling applicable to a great variety of work.

The final question of the quantity producer can now be answered as follows:

I. In quantity work universal types of tools usually equal special equipment in output, and when overhead piloting affords an advantage, standard tools excel.

II. The initial cost of standard, universal types of equipment is usually about the same as that of home-made, special equipment.

III. Universal tooling equipment provides multiple and combined cuts without tool interferences, also rigidity for heavier feeds with low tool cost. In addition, the wide cutting range of the individual tools assures their use for a great variety of work in the future.

Hence, the use of standard tools, wherever possible, greatly reduces the total tooling cost on a long time basis.

Automotive Production

Willys-Knight Production Methods

By Fred H. Colvin
Editor, *American Machinist*

Methods used in selecting and assembling the pistons, pins and connecting rods that will give the best service in the completed engine

THE assembly of Willys-Knight engines, both the 4- and 6-cylinder types, is done on the second floor of a large building. The crankcases are brought up on the elevator shown on the left in Fig. 1, with the bearing caps in place. The cylinder blocks are brought up another elevator farther down the line and meet the crankcases approximately midway between the two sources of supply.

Assembly

The cylinder blocks have the proper pistons selected for the inner sleeves and the sleeves slipped into the bores as in Fig. 2. The cylinder blocks are laid on planks that in turn rest on the rollers of the conveyor that carries them past the bench where the pistons and connecting rods are added to the assembly. It will also be noted that the flattened oil pipe by which the oil rectifier collects the oil from the sleeves, is in place on the 6-cylinder blocks, as well as are all the studs for attaching both the heads and the manifolds.

There is room between the conveyor and the bench behind it for the assemblers to work in comfort. At *A* is the gage by which the connecting-rod holes are tested for squareness. The bar *B* goes through the piston-pin end, the large end goes over the stud *C*, and gages *D* check the parallelism of the bar with the large bore. Then the rods go in the trays at the left, each tray holding a set of six for one engine.

Next to the trays is the arbor press by which the piston pins are pressed into place, through the pistons and connecting rods. At *E* is a special vise for holding the pistons while the binding screws in the rods are being tightened. The pistons rest head down in the pot-chuck and a wrench of the "brace" variety is put through a hole in the side of the piston and enables the operator to clamp the rods

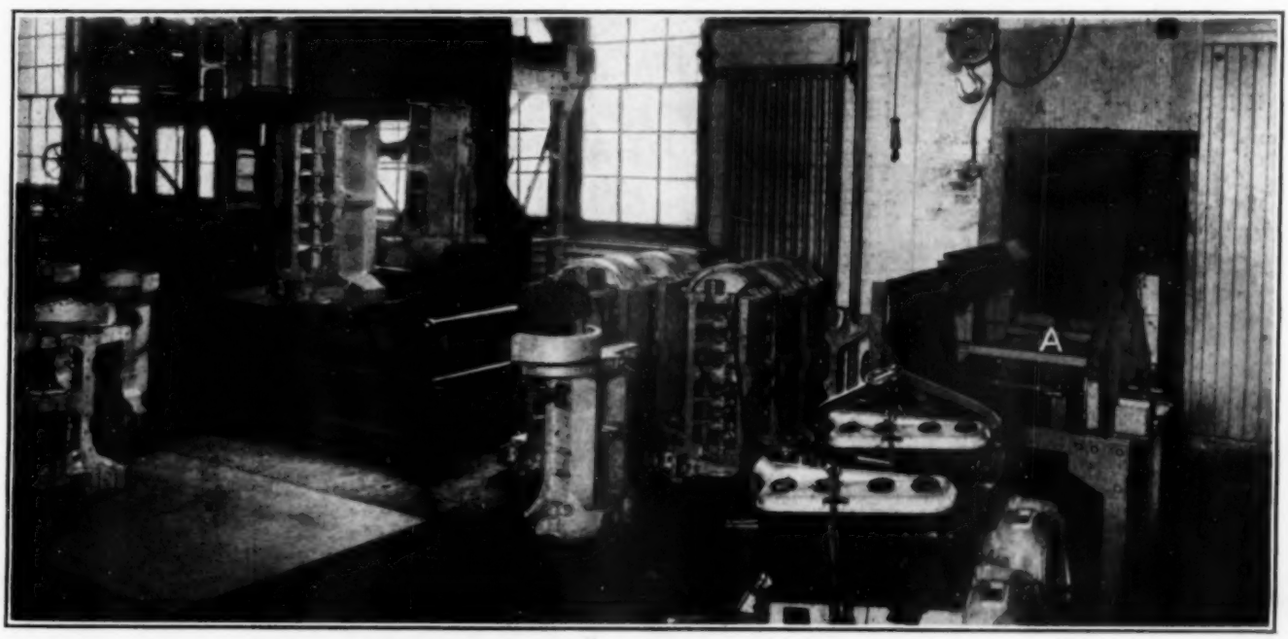


Fig. 1—Where assembly begins and ends

Automotive Production

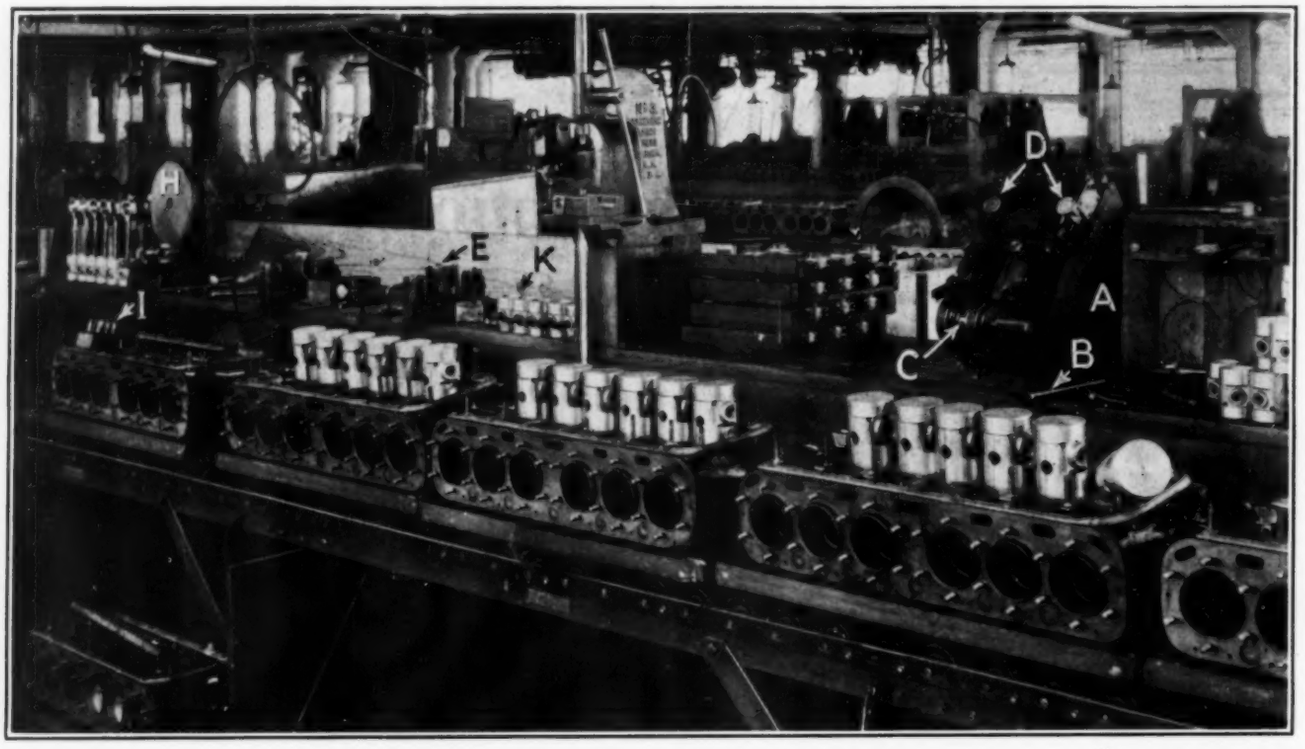


Fig. 2—Getting rod-units ready for assembly

Fig. 3—Weighing the piston-pin fit

on the pins as tight as necessary, without difficulty.

At *H* is a testing device to check the squareness of the piston and the rod. The large end of the rod is put on a stud and the piston is tested against the disk. The inspector's stamps are shown at *I*. The rods and pistons at *K* belong to the block at the left and will be put in place when the block reaches a position in front of the testing device.

Before coming to rod assembly, the pistons have all been tested with the pins that are to go in them, as in Fig. 3. The hole in the piston is sized by forcing through it one of the steel balls at *A*. The balls vary by very small increments. The size of the ball used depends on the fit of the pin, the resistance to turning being weighed by the spring balance and the wrench as shown. The piston is held in the block and the fit tested by noting the pull required to turn the pin in the bearings. After the proper fit has been secured the pin accompanies its piston to the rod assembly.

The crankpin bearing in the large ends of the rods are broached to approximately the right diameter as shown in Fig. 4. The upper end of the broach carries four burnishing rings. The final sizing is done with a steel ball as in Fig. 5, the size being tested with a go and no-go plug. The tolerance is 0.0005 in. If, as occasionally happens, the hole is a trifle small, a second passage of the ball through the hole usually brings it up to the required diameter. The three operations in

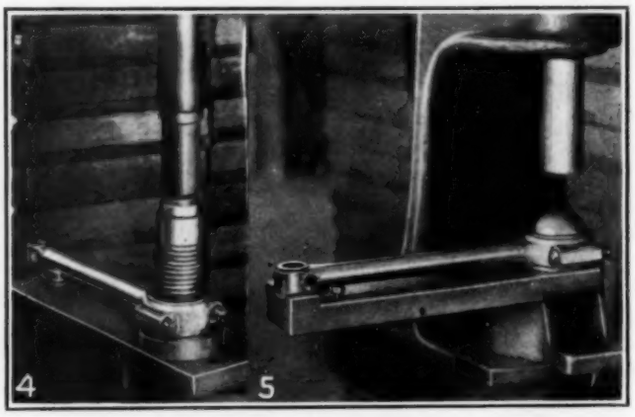
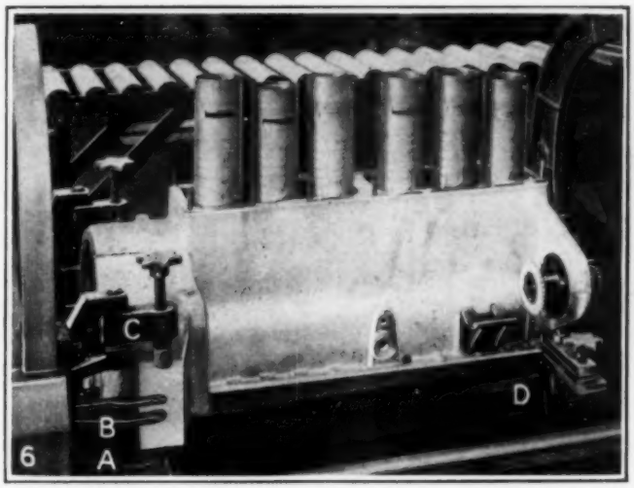


Fig. 4—Broaching connecting-rod bearing. Fig. 5—Burnishing with a steel ball

Automotive Production



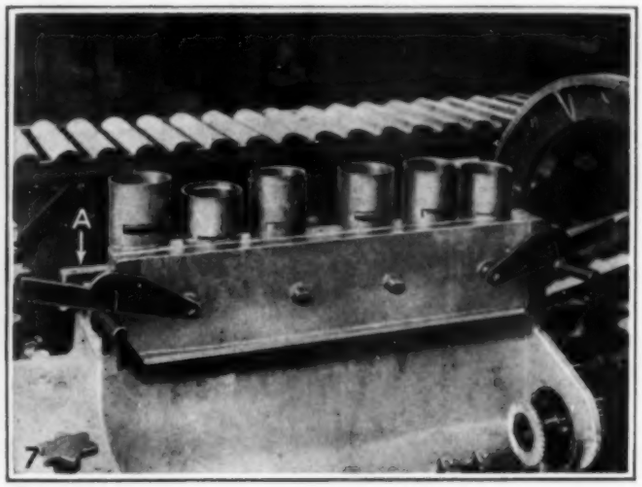


Fig. 6—Getting the sleeves in the crankcase. Fig. 7—Lining up sleeves to receive the cylinder block

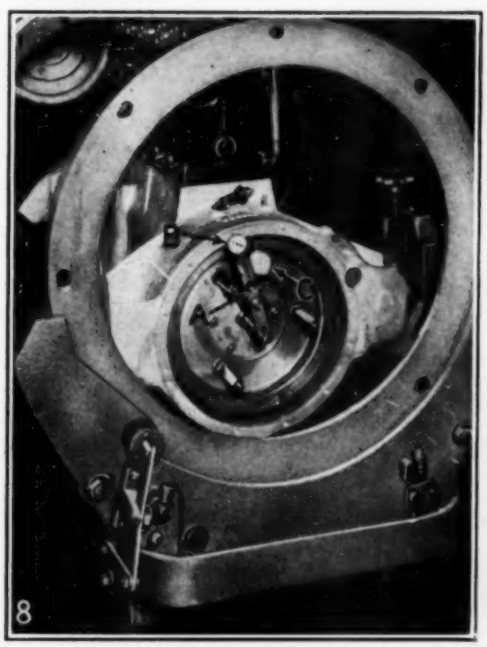
Figs. 3, 4 and 5 give an idea of the great care taken in modern automobile engine building to secure the best results to insure satisfactory operations and long life.

The crankcases in the meantime, are first mounted in a roll-over assembling stand, and the crankshaft, eccentric-sleeve shaft and other parts assembled in place. With each crankcase goes a box containing the sleeve rods and pins, needed in connecting sleeves to the sleeve shaft and the connecting rods to the crankshaft. When the cylinder block and the crankcase meet, the connecting rods are put on the crankshaft and the six pairs of sleeves slipped over the pistons and connected by means of long and short sleeve-rods.

It will be remembered that the sleeve rod has a groove cut in the center of the small hole at the upper end. A round, spring-steel ring, or to be more correct, about three-fourths of a ring, is slipped in this groove. The pin on which the rod bears has a groove in the center, and, when pushed into place, is held against end movement by the spring ring that has snapped into the groove in the pin.

In Fig. 6 the sleeves are in place ready for the cylinder blocks to be put in position. This view shows the different relative positions of the sleeves, three ports being closed and three partly open. It also shows the small slots near the bottom, through which the oil passes to the rectifier. Fig. 6 also shows the substantial way in which the crankcase is held in the arm *A*, in the side arm *B* and by the swinging clamp *C*. At the other end the flange is clamped to a flat surface as at *D*.

With the pistons and sleeves in place, the cylinder block can be lowered over them, and to assist in holding



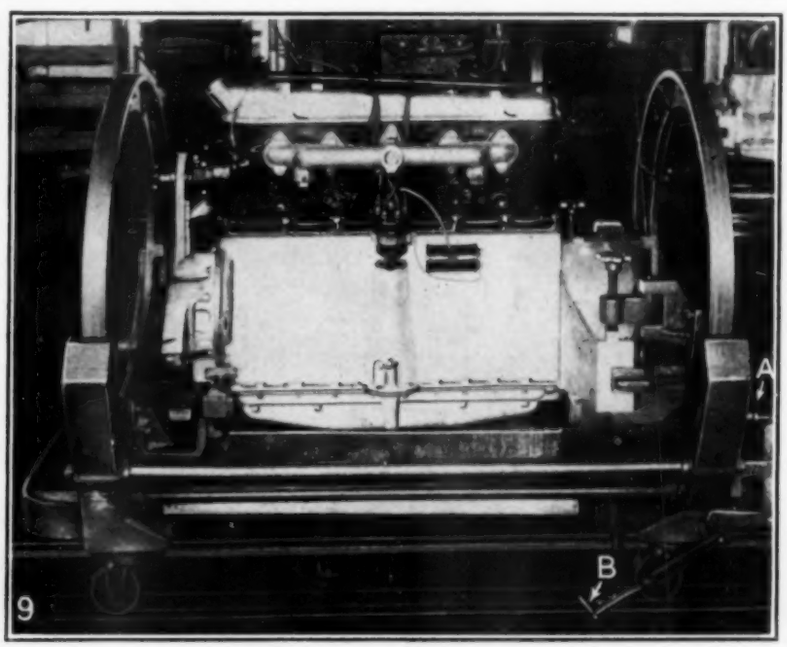
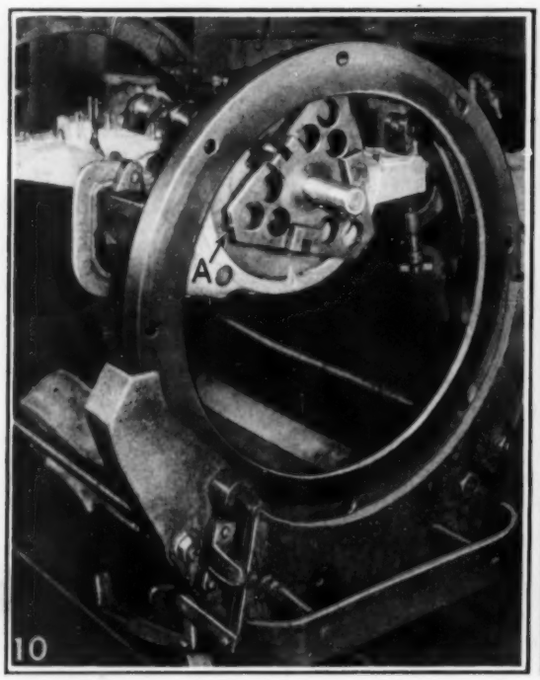


Fig. 8—Testing crankcase end for concentricity. Fig. 9—Completed engine and stand

Automotive Production



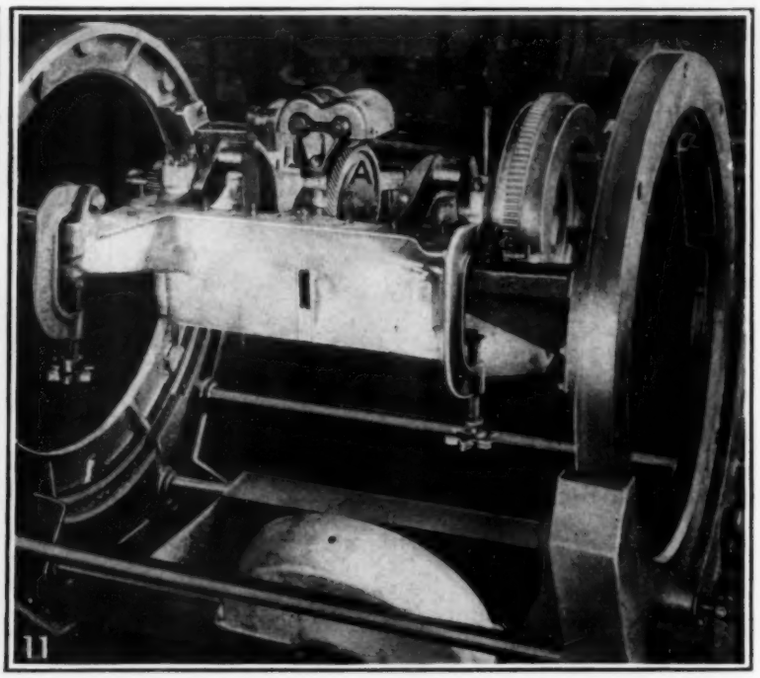


Fig. 10—Checking the end of the 4-cylinder crankcase. Fig. 11—Lanchester balancer in position

the sleeves in line and vertically, the block shown in Fig. 7, is used. This block is made of aluminum, for lightness, and is placed on the crankcase as shown. The bar *A* runs along the other side and holds the sleeves up against the block in a vertical position. With all held firmly, it is an easy matter to slip the cylinder block over them and bolt it in position.

As the engine goes down the line, the end is tested as to the surfaces that receive the bell housing of the transmission case, as in Fig. 8. The arm *A* carries two dial gages, of which *B* tests the squareness of the face with the shaft and *C* tests the concentricity of the bore into which the bell housing fits. The arm and gages are turned with the crankshaft to insure alignment of the transmission with the crankcase.

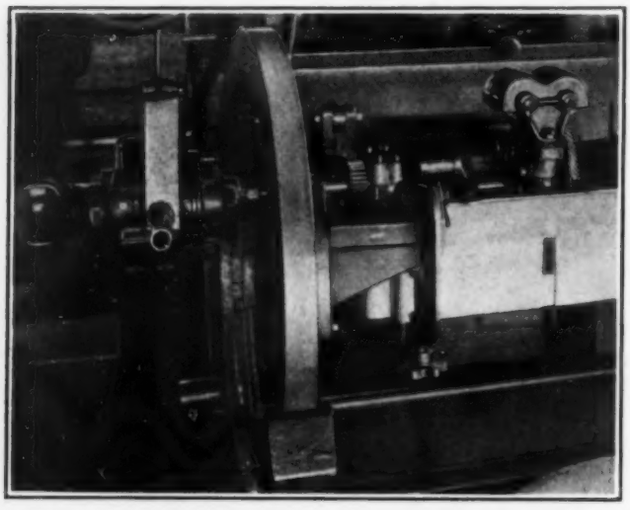


Fig. 12—Running in the balancer by an air motor

The ignition side of the completed engine is shown in Fig. 9. This view shows the complete stand used, including the ball bearing casters, the index pin at *A* and the lever *B* by which the pin can be withdrawn by foot pressure so as to leave both hands free to turn the engine. An end view of the locking arrangement is shown in Fig. 10. The stand rolls on a track composed of one flat rail and one channel, the latter guiding the stand as it travels down the line.

The clamps shown in Fig. 10 are more simple, being practically C-clamps, hinged at one end. Fig. 10 also shows the gage for testing the location of the three clutch-plate studs and their squareness with the shaft. The same gage also tests the concentricity of the bored opening by means of hardened plugs as at *A*, in the three points of the gage. The clutch-plate studs in the 6-cylinder engine are tested in the same way.

The crankcase with its crankshaft are shown in Fig. 11 ready to receive the Lanchester balancer. The crankshaft carries a large helical gear at *A*, that drives one of the balancing weights, the other weight being driven through gears from the first. The weights run at exactly two and one-half times the speed of the crankshaft. After the balancer is bolted in place, it is "run in" by means of an air motor on the end of the crankshaft as in Fig. 12. This motor is connected, started up, and run until the crankcase reaches the station where the cylinder block is put in place.

The assembly line ends just before the conveyor reaches the point shown in Fig. 1, where the crankcases are brought up from the floor below. The completed engine is lifted from the assembly stand by a suitable hoist and placed on the conveyor shown at *A*, Fig. 1, which carries it to the test room where the engine is given several hour's run to limber it up, first by a motor ning test it is ready for assembly into the chassis.

The Design of Gear Tooth Forms

By Earle Buckingham
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Massachusetts Institute of Technology

Tooth and bearing pressures—Simple solution of involute tooth gear problems through the use of involute functions in tabulated form

THE tooth pressure of a gear is the pressure exerted in the direction normal to the tooth profile. This pressure on involute gears is exerted along the line of action. Thus both the direction and the amount of pressure is constant. This is another feature of the involute form which makes it of great value as a gear tooth profile.

Referring to Fig. 32, let

T = tangential force acting at pitch circle of involute
T_1 = tooth pressure
α = pressure angle, then

$$T_1 = \frac{T}{\cos \alpha} \qquad (34)$$

The pressure on the bearings for the gears will be found in a similar manner. Referring again to Fig. 32, let

T_2 = force tending to separate axes of gears, then
$T_2 = T \tan \alpha$.

This force, which tends to separate the axes of the gears, is often confused with the total bearing pressure. As a matter of fact, it is but one component of that force, the other being equal to T. Thus the total bearing pressure for a single pair of gears becomes

$$\text{Bearing pressure} = \sqrt{T^2 + T_2^2} = T_1 = \frac{T}{\cos \alpha} \qquad (35)$$

The total bearing pressure and the tooth pressure on a single pair of gears are equal. When trains of gears are involved, the bearing pressures will be the resultant of the combinations of tooth pressures, referred to the axis of each gear, and must be determined from the combined components of these forces.

A few computations will show that there is only a small difference in tooth pressure or bearing pressure between pressure angles of 14½ deg. and 25 deg.; these angles cover the range most generally used.

For example, let

T = 1,000 lb.
α = 14½ deg.

then $T_1 = \dfrac{1{,}000}{\cos 14\frac{1}{2}\text{ deg.}} = 1{,}035$ lb.

Let T = 1,000 lb.
and α = 25 deg.

then $T_1 = \dfrac{1{,}000}{\cos 25\text{ deg.}} = 1{,}103$ lb.

The pressures are increased less than seven per cent when the pressure angles are increased from 14½ deg. to 25 deg. The greatest effect on the bearing pressure, caused by a change in the pressure angle is a change in its direction.

The seventh article. The eighth will appear in an early issue.

The involute curve has many properties which make it extremely valuable as a gear tooth form. In practice, full advantage of these properties is not always obtained because the method of calculating involute tooth sizes is not generally known. These calculations are sometimes complex, but they are not difficult once the few simple fundamentals have been mastered. It is no more difficult to calculate involute tooth sizes than it is to calculate plane triangles. In fact, an involute gear tooth is a form of triangle; the base is an arc of a circle, while the two similar sides are involute curves. We will, therefore, call the process of calculating involute tooth sizes "involute trigonometry."

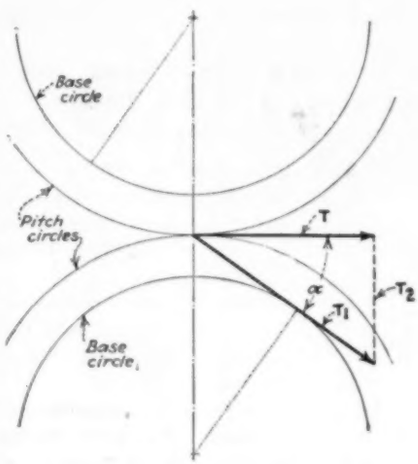


Fig. 32—Tooth pressure acts along the line of action

In Fig. 33 is shown the involute curve. We have derived its equation, which follows, in one of the previous articles. Let

a = radius of base circle
r = length of radius vector
θ = vectorial angle
α = angle between radius vector and a radial line to point of tangency of the generating line with the base circle (this angle on gears is often known as the pressure angle).

Then $$\theta = \tan \alpha - \alpha \qquad (36)$$

and $$r = \frac{a}{\cos \alpha} \qquad (37)$$

These two equations give the fundamental relationships by means of which involute tooth sizes are readily calculated. It will be seen from equation (36) that there is a fixed relationship between the two angles α and θ. The most convenient form of the value of θ is in circular measure, or radians, and its value can be obtained by subtracting the angle α (in radians) from its tangent, as expressed by equation (36). The value θ for any angle α will be called the "involute function" of α and will be expressed as "inv α" in the equations

that follow. Equation (36) has been tabulated, and these tables of involute functions will be used the same as any other trigometric tables. These tables of involute functions together with standard trigometric tables, enable all involute calculations to be made in a similar manner to plane triangles.

The further consideration of involute trigonometry will be in the form of a series of problems. First the necessary equations will be derived and then a definite problem will be solved.

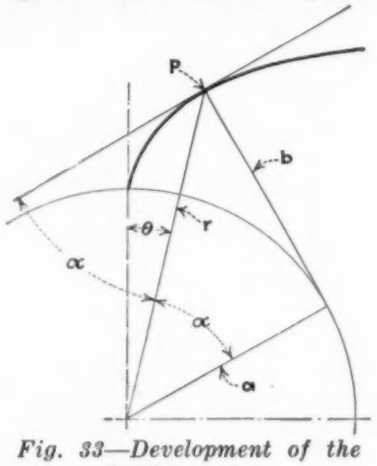


Fig. 33—Development of the involute curve

PROBLEM 6—

Given the tooth thickness and angle a (pressure angle) of an involute gear at a given diameter, to determine its tooth thickness at any other diameter.

Referring to Fig. 34, where

T_1 = the arc thickness of tooth

a_1 = given angle (which would be the *pressure angle* if the given diameter were the *pitch diameter*)

r_1 = radius of given diameter

T_2 = arc thickness of tooth at r_2

r_2 = radius where tooth thickness is required

a_2 = pressure angle at r_2.

As the tooth form is symmetrical, we will deal with the half thickness. The half thickness of the tooth at r_1 in circular measure, or radians, equals $T_1/2r_1$.

The half thickness of the tooth in circular measure at the base circle equals $T_1/2r_1 + \text{inv}\, a_1$. The value of $\text{inv}\, a_1$ is taken from the table of involute functions.

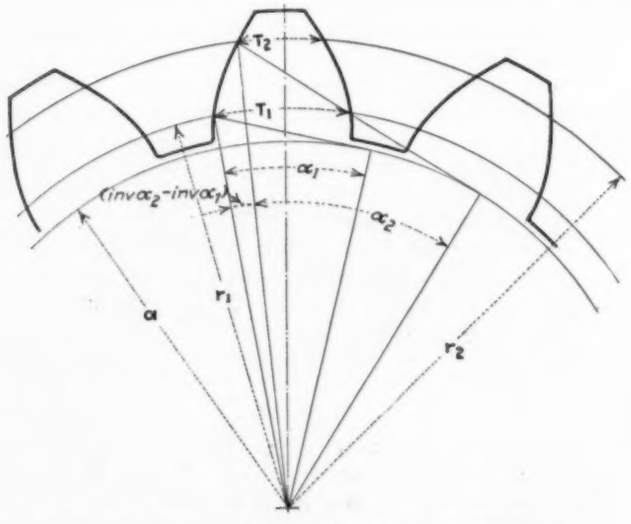


Fig. 34—Determination of the tooth thickness at various diameters

The half thickness of the tooth in circular measure, or radians, at radius r_2 is equal to its thickness, in radians, on the base circle minus the involute function of a_2. The value of a_2 can be determined from equation (37) as follows: Transposing equation (37), we have

$$a = r_1 \cos a_1 \tag{38}$$

$$\cos a_2 = \frac{a}{r_2} = \frac{r_1 \cos a_1}{r_2} \tag{39}$$

We have seen before that

$$\frac{T_2}{2r_2} = \frac{T_1}{2r_1} + \text{inv}\, a_1 - \text{inv}\, a_2$$

whence $$T_2 = 2r_2\left(\frac{T_1}{2r_1} + \text{inv}\, a_1 - \text{inv}\, a_2\right) \tag{40}$$

Thus, to determine the tooth thickness of an involute gear at any diameter, equations (38), (39) and (40) would be solved in the order given. As an example, let

$T_1 = 0.2618$ in.

$a_1 = 20$ deg.

$r_1 = 2.0000$ in.

$r_2 = 2.1250$ in.

From equation (38) we have

$a = 2 \cos 20$ deg. $= 1.8794$ in.

From equation (39) we have

$$\cos a_2 = \frac{1.8794}{2.1250} = 0.88441$$

whence $a_2 = 27° - 49' - 13''$

From equation (40) we have

$$T_2 = 4.250\left[\frac{0.2618}{4.0000} + \text{inv}\, 20° - \text{inv}(27° - 49' - 13'')\right]$$

From the table of involute functions we get

$\text{inv}\, 20° = 0.014904$ radians

$\text{inv}(27° - 49' - 13'') = 0.042138$ radians

whence $T_2 = 4.250(0.06545 + 0.014904 - 0.042138) = 0.1624$ in.

PROBLEM 7—

Given the tooth thickness at one diameter, to determine the diameter where the tooth becomes pointed.

Referring to Fig. 35, let

r_1 = given radius

a_1 = pressure angle at radius r_1

T_1 = tooth thickness at r_1

r_2 = radius where T_2 equals zero.

Referring to equation (40), and making T_2 equal to zero, we would have

$$2r_2\left(\frac{T_1}{2r_1} + \text{inv}\, a_1 - \text{inv}\, a_2\right) = 0$$

Dividing by $2r_2$, we have

$$\frac{T_1}{2r_1} + \text{inv}\, a_1 - \text{inv}\, a_2 = 0$$

Transposing, this becomes

$$\text{inv}\, a_2 = \frac{T_1}{2r_1} + \text{inv}\, a_1 \tag{41}$$

From equation (37) we have

$$r_2 = \frac{a}{\cos a_2} = \frac{r_1 \cos a_1}{\cos a_2} \tag{42}$$

Thus to determine the radius of an involute gear where the tooth would become pointed, equations (41) and (42) would be solved in the order given. As an example, let

$r_1 = 2.0000$ in.

$a_1 = 20$ deg.

$T_1 = 0.2618$ in.

From equation (41) we have

$$\text{inv}\, a_2 = \frac{0.2618}{4.0000} + \text{inv}\, a_1 = 0.06545 + 0.014904 = 0.08035 \text{ radians}$$

From the table of involute functions we find that

$a_2 = 33° - 54' - 22''$

Table I—Values of the Involute Functions of α. Inv α = tan α − α = 0 radians

Min.	0°	1°	2°	3°
0	0 00000 00000 00	0 00000 177	0 00001 418	0 00004 790
1	00 08	186	454	871
2	00 66	196	491	952
3	01 22	205	528	0 00005 034
4	05 25	215	565	117
5	10 26	225	603	201
6	17 72	236	642	286
7	28 14	247	682	372
8	42 01	258	722	458
9	59 81	270	762	546
10	82 05	281	804	634
11	0 00000 00109 20	0 00000 294	0 00001 846	0 00005 724
12	141 78	306	888	814
13	180 26	319	931	906
14	225 14	333	975	998
15	276 91	346	0 00002 020	0 00006 091
16	336 06	360	065	186
17	403 10	375	111	281
18	478 50	389	158	377
19	562 76	404	205	474
20	656 38	420	253	573
21	0 00000 00759 84	0 00000 436	0 00002 301	0 00006 672
22	0873 64	452	351	772
23	0998 27	469	401	873
24	1134 23	486	452	975
25	1281 99	504	503	0 00007 078
26	1442 07	522	555	183
27	1614 95	540	608	288
28	1802 12	559	662	394
29	2001 08	579	716	501
30	2215 31	598	771	610
31	0 00000 02444 31	0 00000 618	0 00002 827	0 00007 719
32	2688 57	639	884	829
33	2948 59	660	941	941
34	3224 86	682	999	0 00008 053
35	3517 87	704	0 00003 058	167
36	3828 10	726	117	281
37	4156 07	749	178	397
38	4502 24	772	239	514
39	4867 13	796	301	632
40	5251 22	821	364	751
41	0 00000 05655 01	0 00000 846	0 00003 427	0 00008 871
42	06078 98	871	491	992
43	06523 63	897	556	0 00009 114
44	06989 46	923	622	237
45	07476 95	950	689	362
46	07986 60	978	757	487
47	08518 89	0 00001 005	825	614
48	09074 33	034	894	742
49	09653 41	063	964	870
50	10256 61	092	0 00004 035	0 00010 000
51	0 00000 10884 43	0 00001 123	0 00004 107	0 00010 132
52	11537 37	153	179	264
53	12215 91	184	252	397
54	12920 56	216	327	532
55	13651 79	248	402	668
56	14410 11	281	478	805
57	15196 00	315	554	943
58	16009 97	349	632	0 00011 082
59	16852 50	383	711	223
60	0 00000 17724 08	0 00001 418	0 00004 790	0 00011 364

Min.	4°	5°	6°	7°
0	0 00011 364	0 00022 220	0 00038 45	0 00061 15
1	507	443	8 77	1 59
2	651	668	9 09	2 03
3	796	894	9 42	2 48
4	943	0 00023 123	9 75	2 92
5	0 00012 090	352	0 00040 08	3 37
6	239	583	0 41	3 82
7	389	816	0 74	4 27
8	541	0 00024 049	1 08	4 73
9	693	284	1 41	5 18
10	847	522	1 75	5 64
11	0 00013 002	0 00024 761	0 00042 09	0 00066 10
12	158	0 00025 001	2 44	6 57
13	316	243	2 78	7 03
14	474	486	3 13	7 50
15	634	731	3 47	7 97
16	796	977	3 82	8 44
17	958	0 00026 225	4 17	8 92
18	0 00014 122	474	4 53	9 39
19	287	726	4 88	9 87
20	453	978	5 24	0 00070 35
21	0 00014 621	0 00027 233	0 00045 60	0 00070 83
22	790	489	5 96	1 32
23	960	746	6 32	1 81
24	0 00015 132	0 00028 005	6 69	2 30
25	305	266	7 06	2 79
26	479	528	7 43	3 28
27	655	792	7 80	3 78
28	831	0 00029 058	8 17	4 28
29	0 00016 010	325	8 54	4 78
30	189	594	8 92	5 28
31	0 00016 370	0 00029 864	0 00049 30	0 00075 79
32	552	0 00030 137	9 68	6 29
33	736	410	0 00050 06	6 80
34	921	686	0 45	7 32
35	0 00017 107	963	0 83	7 83
36	294	0 00031 242	1 22	8 35
37	483	522	1 61	8 87
38	674	804	2 00	9 39
39	866	0 00032 088	2 40	9 91
40	0 00018 059	374	2 80	0 00080 44
41	0 00018 253	0 00032 661	0 00053 19	0 00080 96
42	449	950	3 59	1 50
43	646	0 00033 241	4 00	2 03
44	845	533	4 40	2 56
45	0 00019 045	827	4 81	3 10
46	247	0 00034 123	5 22	3 64
47	450	421	5 63	4 18
48	654	720	6 04	4 73
49	860	0 00035 021	6 45	5 27
50	0 00020 067	324	6 87	5 82
51	0 00020 276	0 00035 628	0 00057 29	0 00086 38
52	486	934	7 71	6 93
53	698	0 00036 242	8 13	7 49
54	911	552	8 56	8 05
55	0 00021 125	864	8 98	8 61
56	341	0 00037 177	9 41	9 17
57	559	492	9 85	9 74
58	778	809	0 00060 28	0 00090 31
59	998	0 00038 128	0 71	0 88
60	0 00022 220	0 00038 448	0 00061 15	0 00091 45

Min.	8°	9°	10°	11°
0	0 00091 45	0 00130 48	0 00179 41	0 00239 41
1	2 03	1 21	0 00180 31	0 00240 51
2	2 60	1 95	1 22	1 61
3	3 18	2 68	2 13	2 72
4	3 77	3 42	3 05	3 83
5	4 35	4 16	3 97	4 95
6	4 94	4 91	4 89	6 07
7	5 53	5 66	5 81	7 19
8	6 12	6 41	6 74	8 31
9	6 72	7 16	7 67	9 44
10	7 32	7 92	8 60	0 00250 57
11	0 00097 92	0 00138 68	0 00189 54	0 00251 71
12	8 52	9 44	0 00190 48	2 85
13	9 13	0 00140 20	1 42	3 99
14	9 73	0 97	2 37	5 13
15	0 00100 34	1 74	3 32	6 28
16	0 96	2 51	4 27	7 44
17	1 57	3 29	5 23	8 59
18	2 19	4 07	6 19	9 75
19	2 81	4 85	7 15	0 00260 91
20	3 43	5 63	8 12	2 08
21	0 00104 06	0 00146 42	0 00199 09	0 00263 25
22	4 69	7 21	0 00200 06	4 43
23	5 32	8 00	1 03	5 60
24	5 95	8 80	2 01	6 78
25	6 59	9 60	2 99	7 97
26	7 22	0 00150 40	3 98	9 16
27	7 86	1 20	4 97	0 00270 35
28	8 51	2 01	5 96	1 54
29	9 15	2 82	6 95	2 74
30	9 80	3 63	7 95	3 94
31	0 00110 45	0 00154 45	0 00208 95	0 00275 15
32	1 11	5 27	9 95	6 36
33	1 76	6 09	0 00210 96	7 57
34	2 42	6 91	1 97	8 79
35	3 08	7 74	2 99	0 00280 01
36	3 75	8 57	4 00	1 23
37	4 41	9 41	5 02	2 46
38	5 08	0 00160 24	6 05	3 69
39	5 75	1 08	7 07	4 93
40	6 43	1 93	8 10	6 16
41	0 00117 11	0 00162 77	0 00219 14	0 00287 41
42	7 79	3 62	0 00220 17	8 65
43	8 47	4 47	1 21	9 90
44	9 15	5 33	2 26	0 00291 15
45	9 84	6 18	3 30	2 41
46	0 00120 53	7 04	4 35	3 67
47	1 22	7 91	5 41	4 94
48	1 92	8 77	6 47	6 20
49	2 62	9 64	7 53	7 47
50	3 32	0 00170 51	8 59	8 75
51	0 00124 02	0 00171 39	0 00229 66	0 00300 03
52	4 73	2 27	0 00230 73	1 31
53	5 44	3 15	1 80	2 60
54	6 15	4 03	2 88	3 89
55	6 87	4 92	3 96	5 18
56	7 58	5 81	5 04	6 48
57	8 30	6 71	6 13	7 78
58	9 03	7 60	7 22	9 08
59	9 75	8 50	8 31	0 00310 39
60	0.00130 48	0.00179 41	0.00239 41	0.00311 71

Table I (continued)—Values of the Involute Functions of α. Inv α = tan α — α = θ radians

Min.	12°	13°	14°	15°
0	0.00311 71	0.00397 54	0.00498 19	0.00614 98
1	3 02	9 09	0.00500 00	7 07
2	4 34	0.00400 65	1 82	9 17
3	5 67	2 21	3 64	0.00621 27
4	6 99	3 77	5 46	3 37
5	8 32	5 34	7 29	5 48
6	9 66	6 92	9 12	7 60
7	0.00321 00	8 49	0.00510 96	9 72
8	2 34	0.00410 08	2 80	0.00631 84
9	3 69	1 66	4 65	3 97
10	5 04	3 25	6 50	6 11
11	0.00326 39	0.00414 85	0.00518 35	0.00638 25
12	7 75	6 44	0.00520 22	0.00640 39
13	9 11	8 05	2 08	2 54
14	0.00330 48	9 65	3 95	4 70
15	1 85	0.00421 26	5 82	6 86
16	3 22	2 88	7 70	9 02
17	4 60	4 50	9 58	0.00651 19
18	5 98	6 12	0.00531 47	3 37
19	7 36	7 75	3 36	5 55
20	8 75	9 38	5 26	7 73
21	0.00340 14	0.00431 02	0.00537 16	0.00659 92
22	1 54	2 66	9 07	0.00662 11
23	2 94	4 30	0.00540 98	4 31
24	4 34	5 95	2 90	6 52
25	5 75	7 60	4 82	8 73
26	7 16	9 26	6 74	0.00670 94
27	8 58	0.00440 92	8 67	3 16
28	0.00350 00	2 59	0.00550 60	5 39
29	1 42	4 26	2 54	7 62
30	2 85	5 93	4 48	9 85
31	0.00354 28	0.00447 61	0.00556 43	0.00682 09
32	5 72	9 29	8 38	4 34
33	7 16	0.00450 98	0.00560 34	6 59
34	8 60	2 67	2 30	8 84
35	0.00360 05	4 37	4 27	0.00691 10
36	1 50	6 07	6 24	3 37
37	2 96	7 77	8 22	5 64
38	4 41	9 48	0.00570 20	7 91
39	5 88	0.00461 20	2 18	0.00700 19
40	7 35	2 91	4 17	2 48
41	0.00368 82	0.00464 64	0.00576 17	0.00704 77
42	0.00370 29	6 36	8 17	7 06
43	1 77	8 09	0.00580 17	9 36
44	3 26	9 83	2 18	0.00711 67
45	4 74	0.00471 57	4 20	3 98
46	6 23	3 31	6 22	2 30
47	7 73	5 06	8 24	8 62
48	9 23	6 81	0.00590 28	0.00720 95
49	0.00380 73	8 57	2 30	3 28
50	2 24	0.00480 33	4 34	5 61
51	0.00383 75	0.00482 10	0.00596 38	0.00727 96
52	5 27	3 87	8 43	0.00730 30
53	6 79	5 64	0.00600 48	2 66
54	8 31	7 42	2 54	5 01
55	9 84	9 21	4 60	7 38
56	0.00391 37	0.00490 99	6 67	9 75
57	2 91	2 79	8 74	0.00742 12
58	4 45	4 58	0.00610 81	4 50
59	5 99	6 39	2 89	6 88
60	0.00397 54	0.00498 19	0.00614 98	0.00749 27

Min.	16°	17°	18°	19°	20°
0	0.00749 3	0.00902 5	0.01076 0	0.01271 5	0.01490 4
1	51 7	05 2	79 1	75 0	94 3
2	54 1	07 9	82 2	78 4	98 2
3	56 5	10 7	85 3	81 9	0.01502 0
4	58 9	13 4	88 4	85 4	05 9
5	61 3	16 1	91 5	88 8	09 8
6	63 7	18 9	94 6	92 3	13 7
7	66 1	21 6	97 7	95 8	17 6
8	68 6	24 4	0.01100 8	99 3	21 5
9	71 0	27 2	03 9	0.01302 8	25 4
10	73 5	29 9	07 1	06 3	29 3
11	0.00775 9	0.00932 7	0.01110 2	0.01309 8	0.01533 3
12	78 4	35 5	13 3	13 4	37 2
13	80 8	38 3	16 5	16 9	41 1
14	83 3	41 1	19 6	20 4	45 1
15	85 7	43 9	22 8	24 0	49 0
16	88 2	46 7	26 0	27 5	53 0
17	90 7	49 5	29 1	31 1	57 0
18	93 2	52 3	32 3	34 6	60 9
19	95 7	55 2	35 5	38 2	64 9
20	98 2	58 0	38 7	41 8	68 9
21	0.00800 7	0.00960 8	0.01141 9	0.01345 4	0.01572 9
22	03 2	63 7	45 1	49 0	76 9
23	5 7	66 5	48 3	52 6	80 9
24	08 2	69 4	51 5	56 2	85 0
25	10 7	72 2	54 7	59 8	89 0
26	13 3	75 1	58 0	63 4	93 0
27	15 8	78 0	61 2	67 0	97 1
28	18 3	80 8	64 4	70 7	0.01601 1
29	20 9	83 7	67 7	74 3	05 2
30	23 4	86 6	70 9	77 9	09 2
31	0.00826 0	0.00989 5	0.01174 2	0.01381 6	0.01613 3
32	28 5	92 4	77 5	85 2	17 4
33	31 1	95 3	80 7	88 9	21 5
34	33 7	98 2	84 0	92 6	25 5
35	36 2	0.01001 2	87 3	96 3	29 6
36	38 8	04 1	90 6	99 9	33 7
37	41 4	07 0	93 9	0.01403 6	37 9
38	44 0	09 9	97 2	07 3	42 0
39	46 6	12 9	0.01200 5	11 0	46 1
40	49 2	15 8	03 8	14 8	50 2
41	0.00851 8	0.01018 8	0.01207 1	0.01418 5	0.01654 4
42	54 4	21 7	10 5	22 2	58 5
43	57 1	24 7	13 8	25 9	62 7
44	59 7	27 7	17 2	29 7	66 9
45	62 3	30 7	20 5	33 4	71 0
46	65 0	33 6	23 9	37 2	75 2
47	67 6	36 6	27 2	40 9	79 4
48	70 2	39 6	30 6	44 7	83 6
49	72 9	42 6	34 0	48 5	87 8
50	75 6	45 6	37 3	52 3	92 0
51	0.00878 2	0.01048 6	0.01240 7	0.01456 0	0.01696 2
52	80 9	51 7	44 1	59 8	0.01700 4
53	83 6	54 7	47 5	63 6	04 7
54	86 3	57 7	50 9	67 4	08 9
55	88 9	60 8	54 3	71 3	13 2
56	91 6	63 8	57 8	75 1	17 4
57	94 3	66 9	61 2	78 9	21 7
58	97 0	69 9	64 6	82 7	25 9
59	99 8	73 0	68 1	86 6	30 2
60	0.00902 5	0.01076 0	0.01271 5	0.01490 4	0.01734 5

Min.	21°	22°	23°	24°	25°
0	0.01734 5	0.02005 4	0.02304 9	0.02635 0	0.02997 5
1	38 8	10 1	10 2	40 7	0.03003 9
2	43 1	14 9	15 4	46 5	10 2
3	47 4	19 7	20 7	52 3	16 6
4	51 7	24 4	25 9	58 1	22 9
5	56 0	29 2	31 2	63 9	29 3
6	60 3	34 0	36 5	69 7	35 7
7	64 7	38 8	41 8	75 6	42 0
8	69 0	43 6	47 1	81 4	48 4
9	73 4	48 4	52 4	87 2	54 9
10	77 7	53 3	57 7	93 1	61 3
11	0.01782 1	0.02058 1	0.02363 1	0.02698 9	0.03067 7
12	86 5	62 9	68 4	0.02704 8	74 1
13	90 8	67 8	73 8	10 7	80 6
14	95 2	72 6	79 1	16 6	87 0
15	99 6	77 5	84 5	22 5	93 5
16	0.01804 0	82 4	89 9	28 4	0.03100 0
17	08 4	87 3	95 2	34 3	06 5
18	12 9	92 1	0.02400 6	40 2	13 0
19	17 3	97 0	06 0	46 2	19 5
20	21 7	0.02101 9	11 4	52 1	26 0
21	0.01826 2	0.02106 9	0.02416 9	0.02758 1	0.03132 5
22	30 6	11 8	22 3	64 0	39 0
23	35 1	16 7	27 7	70 0	45 6
24	39 5	21 7	33 2	76 0	52 1
25	44 0	26 6	38 6	82 0	58 7
26	48 5	31 6	44 1	88 0	65 3
27	53 0	36 5	49 5	94 0	71 8
28	57 5	41 5	55 0	0.02800 0	78 4
29	62 0	46 5	60 5	06 0	85 0
30	66 5	51 4	66 0	12 1	91 7
31	0.01871 0	0.02156 4	0.02471 5	0.02818 1	0.03198 3
32	75 5	61 4	77 0	24 2	0.03204 9
33	80 0	66 5	82 5	30 2	11 6
34	84 6	71 5	88 1	36 3	18 2
35	89 1	76 5	93 6	42 4	24 9
36	93 7	81 5	99 2	48 5	31 5
37	98 3	86 6	0.02504 7	54 6	38 2
38	0.01902 8	91 6	10 3	60 7	44 9
39	07 4	96 7	15 9	66 8	51 6
40	12 0	0.02201 8	21 4	72 9	58 3
41	0.01916 6	0.02206 8	0.02527 0	0.02879 1	0.03265 1
42	21 2	11 9	32 6	85 2	71 8
43	25 8	17 0	38 2	91 4	78 5
44	30 4	22 1	43 9	97 6	85 3
45	35 0	27 2	49 5	0.02903 7	92 0
46	39 7	32 4	55 1	09 9	98 8
47	44 3	37 5	60 8	16 1	0.03305 6
48	49 0	42 6	66 4	22 3	12 4
49	53 6	47 8	72 1	28 5	19 2
50	58 3	52 9	77 8	34 8	26 0
51	0.01963 0	0.02258 1	0.02583 4	0.02941 0	0.03332 8
52	67 6	63 3	89 1	47 2	39 7
53	72 3	68 4	94 8	53 5	46 5
54	77 0	73 6	0.02600 5	59 8	53 4
55	81 7	78 8	06 2	66 0	60 2
56	86 4	84 0	12 0	72 3	67 1
57	91 2	89 2	17 7	78 6	74 0
58	95 9	94 4	23 5	84 9	80 9
59	0.02000 7	99 7	29 2	91 2	87 8
60	0.02005 4	0.02304 9	0.02635 0	0.02997 5	0.03394 7

Table I (continued)—Values of the Involute Functions of α. Inv α = tan α — α = θ radians

Min.	26°	27°	28°	29°	30°
0	0.03394 7	0.03828 7	0.04301 7	0.04816 4	0.05375 1
1	0.03401 6	36 2	10 0	25 3	84 9
2	08 6	43 8	18 2	34 3	94 6
3	15 5	51 4	26 4	43 2	0.05404 3
4	22 5	59 0	34 7	52 2	14 0
5	29 4	66 6	43 0	61 2	23 8
6	36 4	74 2	51 3	70 2	33 6
7	43 4	81 8	59 6	79 2	43 3
8	50 4	89 4	67 9	88 3	53 1
9	57 4	97 1	76 2	97 3	62 9
10	64 4	0.03904 7	84 5	0.04906 4	72 8
11	0.03471 4	0.03912 4	0.04392 9	0.04915 4	0.05482 6
12	78 5	20 1	0.04401 2	24 5	92 4
13	85 5	27 8	09 6	33 6	0.05502 3
14	92 6	35 5	18 0	42 7	12 2
15	99 7	43 2	26 4	51 8	22 1
16	0.03506 7	50 9	34 8	60 9	32 0
17	13 8	58 6	43 2	70 1	41 9
18	20 9	66 4	51 6	79 2	51 8
19	28 0	74 1	60 1	88 4	61 7
20	35 2	81 9	68 5	97 6	71 7
21	0.03542 3	0.03989 7	0.04477 0	0.05006 8	0.05581 7
22	49 4	97 4	85 5	16 0	91 6
23	56 6	0.04005 2	93 9	25 2	0.05601 6
24	63 7	13 1	0.04502 4	34 4	11 6
25	70 9	20 9	11 0	43 7	21 7
26	78 1	28 7	19 5	52 9	31 7
27	85 3	36 6	28 0	62 2	41 7
28	92 5	44 4	36 6	71 5	51 8
29	99 7	52 3	45 1	80 8	61 9
30	0.03606 9	60 2	53 7	90 1	72 0
31	0.03614 2	0.04068 0	0.04562 3	0.05099 4	0.05682 1
32	21 4	75 9	70 9	0.05108 7	92 2
33	28 7	83 9	79 5	18 1	0.05702 3
34	35 9	91 8	88 1	27 4	12 4
35	43 2	99 7	96 7	36 8	22 6
36	50 5	0.04107 6	0.04605 4	46 2	32 8
37	57 8	15 6	14 0	55 6	42 9
38	65 1	23 6	22 7	65 0	53 1
39	72 4	31 6	31 3	74 4	63 3
40	79 8	39 5	40 0	83 8	73 6
41	0.03687 1	0.04147 5	0.04648 7	0.05193 3	0.05783 8
42	94 5	55 6	57 5	0.05202 7	94 0
43	0.03701 8	63 6	66 2	12 2	0.05804 3
44	09 2	71 6	74 9	21 7	14 6
45	16 6	79 7	83 7	31 2	24 9
46	24 0	87 7	92 4	40 7	35 2
47	31 4	95 8	0.04701 2	50 2	45 5
48	38 8	0.04203 9	10 0	59 7	55 8
49	46 2	12 0	18 8	69 3	66 2
50	53 7	20 1	27 6	78 8	76 5
51	0.03761 1	0.04228 2	0.04736 4	0.05288 4	0.05886 9
52	68 6	36 3	45 2	98 0	97 3
53	76 1	44 4	54 1	0.05307 6	0.05907 7
54	83 5	52 6	63 0	17 2	18 1
55	91 0	60 7	71 8	26 8	28 5
56	98 5	68 9	80 7	36 5	39 0
57	0.03806 0	77 1	89 6	46 1	49 4
58	13 6	85 3	98 5	55 8	59 9
59	21 1	93 5	0.04807 4	65 5	70 4
60	0.03828 7	0.04301 7	0.04816 4	0.05375 1	0.05980 9

Min.	31°	32°	33°	34°	35°
0	0.05980 9	0.06636 4	0.07344 9	0.08109 7	0.08934 2
1	91 4	47 8	57 2	22 9	48 5
2	0.06001 9	59 1	69 5	36 2	62 8
3	12 4	70 5	81 8	49 4	77 1
4	23 0	81 9	94 1	62 7	91 4
5	33 5	93 4	0.07406 4	76 0	0.09005 8
6	44 1	0.06704 8	18 8	89 4	20 1
7	54 7	16 3	31 2	0.08202 7	34 5
8	65 3	27 7	43 5	16 1	48 9
9	75 9	39 2	55 9	29 4	63 3
10	86 6	50 7	68 4	42 8	77 7
11	0.06097 2	0.06762 2	0.07480 8	0.08256 2	0.09092 2
12	0.06107 9	73 8	93 2	69 7	0.09106 7
13	18 6	85 3	0.07505 7	83 1	21 1
14	29 2	96 9	18 2	96 6	35 6
15	40 0	0.06808 4	30 7	0.08310 0	50 2
16	50 7	20 0	43 2	23 5	64 7
17	61 4	31 6	55 7	37 1	79 3
18	72 1	43 2	68 3	50 6	93 8
19	82 9	54 9	80 8	64 1	0.09208 4
20	93 7	66 5	93 4	77 7	23 0
21	0.06204 5	0.06878 2	0.07606 0	0.08391 3	0.09237 7
22	15 3	89 9	18 6	0.08404 9	52 3
23	26 1	0.06901 6	31 2	18 5	67 0
24	36 9	13 3	43 9	32 1	81 6
25	47 8	25 0	56 5	45 7	96 3
26	58 6	36 7	69 2	59 4	0.09311 1
27	69 5	48 5	81 9	73 1	25 8
28	80 4	60 2	94 6	86 8	40 6
29	91 3	72 0	0.07707 3	0.08500 5	55 3
30	0.06302 2	83 8	20 0	14 2	70 1
31	0.06313 1	0.06995 6	0.07732 8	0.08528 0	0.09384 9
32	24 1	0.07007 5	45 5	41 8	99 8
33	35 0	19 3	58 3	55 5	0.09414 6
34	46 0	31 2	71 1	69 3	29 5
35	57 0	43 0	83 9	83 2	44 3
36	68 0	54 9	96 8	97 0	59 2
37	79 0	66 8	0.07809 6	0.08610 8	74 2
38	90 1	78 7	22 5	24 7	89 1
39	0.06401 1	90 7	35 4	38 6	0.09504 1
40	12 2	0.07102 6	48 3	52 5	19 0
41	0.06423 2	0.07114 6	0.07861 2	0.08666 4	0.09534 0
42	34 3	26 6	74 1	80 4	49 0
43	45 4	38 6	87 1	94 3	64 1
44	56 5	50 6	0.07900 0	0.08708 3	79 1
45	67 7	62 6	13 0	22 3	94 2
46	78 8	74 7	26 0	36 3	0.09609 3
47	90 0	86 7	39 0	50 3	24 4
48	0.06501 2	98 8	52 0	64 4	39 5
49	12 3	0.07210 9	65 1	78 4	54 6
50	23 6	23 0	78 1	92 5	69 8
51	0.06534 8	0.07235 1	0.07991 2	0.08806 6	0.09685 0
52	46 0	47 3	0.08004 3	20 7	0.09700 2
53	57 3	59 4	17 4	34 8	15 4
54	68 5	71 6	30 6	49 0	30 6
55	79 8	83 8	43 7	63 1	45 9
56	91 1	95 9	56 9	77 3	61 1
57	0.06602 4	0.07308 2	70 0	91 5	76 4
58	13 7	20 4	83 2	0.08905 7	91 7
59	25 0	32 6	96 4	20 0	0.09807 1
60	0.06636 4	0.07344 9	0.08109 7	0.08934 2	0.09822 4

Min.	36°	37°	38°	39°	40°
0	0.09822	0.10778	0.11806	0.12911	0.14097
1	838	795	824	930	117
2	853	811	842	949	138
3	869	828	859	968	158
4	884	844	877	987	179
5	899	861	895	0.13006	200
6	915	878	913	025	220
7	930	894	931	045	241
8	946	911	949	064	261
9	961	928	957	083	282
10	977	944	985	102	303
11	0.09992	0.10961	0.12003	0.13122	0.14324
12	0.10008	978	021	141	344
13	024	995	039	160	365
14	039	0.11011	057	180	386
15	055	028	075	199	407
16	070	045	093	219	428
17	086	062	111	238	448
18	102	079	129	258	469
19	118	096	147	277	490
20	133	113	165	297	511
21	0.10149	0.11130	0.12184	0.13316	0.14532
22	165	146	202	336	553
23	181	163	220	355	574
24	196	180	238	375	595
25	212	197	257	395	616
26	228	215	275	414	638
27	244	232	293	434	659
28	260	249	312	454	680
29	276	266	330	473	701
30	292	283	348	493	722
31	0.10308	0.11300	0.12367	0.13513	0.14743
32	323	317	385	533	765
33	339	334	404	553	786
34	355	352	422	572	807
35	371	369	441	592	829
36	388	386	459	612	850
37	404	403	478	632	871
38	420	421	496	652	893
39	436	438	515	672	914
40	452	455	534	692	936
41	0.10468	0.11473	0.12552	0.13712	0.14957
42	484	490	571	732	979
43	500	507	590	752	0.15000
44	516	525	608	772	022
45	533	542	627	792	043
46	549	560	646	812	065
47	565	577	664	833	087
48	581	595	683	853	108
49	598	612	702	873	130
50	614	630	721	893	152
51	0.10630	0.11647	0.12740	0.13913	0.15173
52	647	665	759	934	195
53	663	682	778	954	217
54	679	700	797	974	239
55	696	718	815	995	261
56	712	735	834	0.14015	282
57	729	753	853	035	304
58	745	771	872	056	326
59	762	788	891	076	348
60	0.10778	0.11806	0.12911	0.14097	0.15370

Table I (continued)—Values of the Involute Functions of α. Inv α = tan α — α = θ radians

Min.	41°	42°	43°	44°	45°
0	0.15370	0.16737	0.18202	0 19774	0 21460
1	392	760	228	802	489
2	414	784	253	829	518
3	436	807	278	856	548
4	458	831	304	883	577
5	480	855	329	910	606
6	503	879	355	938	635
7	525	902	380	965	665
8	547	926	406	992	694
9	569	950	431	0.20020	723
10	591	974	457	047	753
11	0.15614	0.16998	0.18482	0.20075	0.21782
12	636	0.17022	508	102	812
13	658	045	534	130	841
14	680	069	559	157	871
15	703	093	585	185	900
16	725	117	611	212	930
17	748	142	637	240	960
18	770	166	662	268	989
19	793	190	688	296	0.22019
20	815	214	714	323	049
21	0.15838	0.17238	0.18740	0.20351	0.22079
22	860	262	766	379	108
23	883	286	792	407	138
24	905	311	818	435	168
25	928	335	844	463	198
26	950	359	870	490	228
27	973	383	896	518	258
28	996	408	922	546	288
29	0.16019	432	948	575	318
30	041	457	975	603	348
31	0.16064	0.17481	0 19001	0.20631	0.22378
32	087	506	027	659	409
33	110	530	053	687	439
34	133	555	080	715	469
35	156	579	106	743	499
36	178	604	132	772	530
37	201	628	159	800	560
38	224	653	185	828	590
39	247	678	212	857	621
40	270	702	238	885	651
41	0.16293	0.17727	0.19265	0.20914	0.22682
42	317	752	291	942	712
43	340	777	318	971	743
44	363	801	344	999	773
45	386	826	371	0.21028	804
46	409	851	398	056	835
47	432	876	424	085	865
48	456	901	451	114	896
49	479	926	478	142	927
50	502	951	505	171	958
51	0.16525	0 17976	0.19532	0.21200	0.22989
52	549	0.18001	558	229	0.23020
53	572	026	585	257	050
54	596	051	612	286	081
55	619	076	639	315	112
56	642	101	666	344	143
57	666	127	693	373	174
58	689	152	720	402	206
59	713	177	747	431	237
60	0.16737	0.18202	0.19774	0.21460	0.23268

Min.	46°	47°	48°	49°	50°
0	0 23268	0.25206	0.27285	0 29516	0 31909
1	299	240	321	554	950
2	330	273	357	593	992
3	362	307	393	631	0 32033
4	393	341	429	670	075
5	424	374	465	709	116
6	456	408	501	747	158
7	487	442	538	786	199
8	519	475	574	825	241
9	550	509	610	864	283
10	582	543	646	903	324
11	0 23613	0.25577	0.27683	0 29942	0 32366
12	645	611	719	981	408
13	676	645	755	0 30020	450
14	708	679	792	059	492
15	740	713	828	098	534
16	772	747	865	137	576
17	803	781	902	177	618
18	835	815	938	216	661
19	867	819	975	255	703
20	899	883	0 28012	0 30295	745
21	0.23931	0 25918	0 28048	0.30334	0 32787
22	963	952	085	374	830
23	995	986	122	413	872
24	0 24027	0 26021	159	453	915
25	059	055	196	492	957
26	091	089	233	532	0.33000
27	123	124	270	572	042
28	156	159	307	611	085
29	188	193	344	651	128
30	220	228	381	691	171
31	0 24253	0 26262	0 28418	0 30731	0 33213
32	285	297	455	771	256
33	317	332	493	811	299
34	350	368	530	851	342
35	382	401	567	891	385
36	415	436	605	931	428
37	447	471	642	971	471
38	480	506	680	0 31012	515
39	512	541	717	052	558
40	545	576	755	092	601
41	0.24578	0 26611	0 28792	0 31133	0 33645
42	611	646	830	173	688
43	643	682	868	214	731
44	676	717	906	254	775
45	709	752	943	295	818
46	742	787	981	335	862
47	775	823	0.29019	376	906
48	808	858	057	417	949
49	841	893	095	457	993
50	874	929	133	498	0 34037
51	0 24907	0 26964	0.29171	0 31539	0 34081
52	940	0.27000	209	580	125
53	973	035	247	621	169
54	0.25006	071	286	662	213
55	040	107	324	703	257
56	073	142	362	744	301
57	106	178	400	785	345
58	140	214	439	826	389
59	173	250	477	868	434
60	0.25206	0.27285	0.29516	0.31909	0 34478

Min.	51°	52°	53°	54°	55°
0	0 34478	0 37237	0 40202	0.43390	0.46822
1	522	285	253	446	881
2	567	332	305	501	940
3	611	380	356	556	0.47000
4	656	428	407	611	060
5	700	476	459	667	119
6	745	524	511	722	179
7	790	572	562	778	239
8	834	620	614	833	299
9	879	668	666	889	359
10	924	716	717	945	419
11	0 34969	0.37765	0 40769	0.44001	0.47479
12	0.35014	813	821	057	539
13	059	861	873	113	599
14	104	910	925	169	660
15	149	958	977	225	720
16	194	0.38007	0.41030	281	780
17	240	055	082	337	841
18	285	104	134	393	902
19	330	153	187	450	962
20	376	202	239	506	0.48023
21	0 35421	0.38251	0.41292	0.44563	0.48084
22	467	299	344	619	145
23	512	348	397	676	206
24	558	397	450	733	267
25	604	446	502	789	328
26	649	496	555	846	389
27	695	545	608	903	451
28	741	594	661	960	512
29	787	643	714	0.45017	574
30	833	693	767	047	635
31	0 35879	0 38742	0 41820	0.45132	0.48697
32	925	792	874	189	758
33	971	841	927	246	820
34	0 36017	891	980	304	882
35	063	941	0 42034	361	944
36	110	990	087	419	0.49006
37	156	0 39040	141	476	068
38	202	090	194	534	130
39	249	140	248	592	192
40	295	190	302	650	255
41	0 36342	0 39240	0 42355	0 45708	0.49317
42	388	290	409	766	380
43	435	340	463	824	442
44	482	390	517	882	505
45	529	441	571	940	568
46	575	491	625	998	630
47	622	541	680	0.46057	693
48	669	592	734	115	756
49	716	642	788	173	819
50	763	693	843	232	882
51	0 36810	0 39743	0 42897	0 46291	0 49945
52	858	794	952	349	0 50009
53	905	845	0 43006	408	072
54	952	896	061	467	135
55	999	947	116	526	199
56	0 37047	998	171	585	263
57	094	0 40049	225	644	326
58	142	100	280	703	390
59	189	151	335	762	454
60	0 37237	0 40202	0 43390	0.46822	0 50518

From equation (42) we have

$$r_2 = \frac{2\cos 20°}{\cos 33°-54'-22''} = \frac{2 \times 0.93969}{0.82995} = 2.2644 \text{ in.}$$

PROBLEM 8—

Given the tooth thicknesses of a pair of mating gears, to determine the center distance at which they will mesh tightly.

Referring to Fig. 36, let

r_1 = radius of smaller gear where tooth thickness is known
t_1 = tooth thickness at r_1
n = number of teeth in smaller gear
a_1 = pressure angle at r_1 and R_1
R_1 = radius of larger gear where tooth thickness is known
T_1 = tooth thickness at R_1
N = number of teeth in larger gear
r_2 = pitch radius of smaller gear when in mesh
t_2 = tooth thickness at r_2
a_2 = pressure angle at r_2 and R_2
R_2 = pitch radius of larger gear when in mesh
T_2 = tooth thickness at R_2
C_1 = center distance for pressure angle of a_1
C_2 = center distance for pressure angle of a_2.

From equation (40) we get the tooth thicknesses at r_2 and R_2 as follows,

$$t_2 = 2r_2\left(\frac{t_1}{2r_1} + \text{inv}\, a_1 - \text{inv}\, a_2\right)$$

$$T_2 = 2R_2\left(\frac{T_1}{2R_1} + \text{inv}\, a_1 - \text{inv}\, a_2\right)$$

As the sum of these two tooth thicknesses must be equal to the circular pitch, which in turn is equal to the quotient of the circumference of either pitch circle divided by its number of teeth, we have

$$t_2 + T_2 = \frac{2\pi r_2}{n}$$

Furthermore, we know that the pitch diameters of two mating gears are directly proportional to their numbers of teeth, whence we have

$$R_1 = \frac{N}{n} r_1 \quad \text{and} \quad R_2 = \frac{N}{n} r_2$$

Substituting these values in the equation for T_2, we have

$$T_2 = \frac{2N}{n} r_2\left(\frac{T_1 n}{2Nr_1} + \text{inv}\, a_1 - \text{inv}\, a_2\right)$$

whence

$$t_2 + T_2 = \frac{2\pi r_2}{n} = 2r_2\left[\frac{t_1}{2r_1} + \text{inv}\, a_1 - \text{inv}\, a_2 + \frac{N}{n}\left(\frac{T_1 n}{2Nr_1} + \text{inv}\, a_1 - \text{inv}\, a_2\right)\right]$$

By combining terms, simplifying, and solving for a_2, this equation becomes

$$\text{inv}\, a_2 = \frac{n(t_1 + T_1) - 2\pi r_1}{2r_1(n + N)} + \text{inv}\, a_1 \qquad (43)$$

From equation (37) we have

$$r_2 = \frac{r_1 \cos a_1}{\cos a_2} \quad \text{and} \quad R_2 = \frac{R_1 \cos a_1}{\cos a_2}$$

Also we know that

$$r_1 + R_1 = C_1 \quad \text{and} \quad r_2 + R_2 = C_2$$

whence

$$C_2 = \frac{C_1 \cos a_1}{\cos a_2} \qquad (44)$$

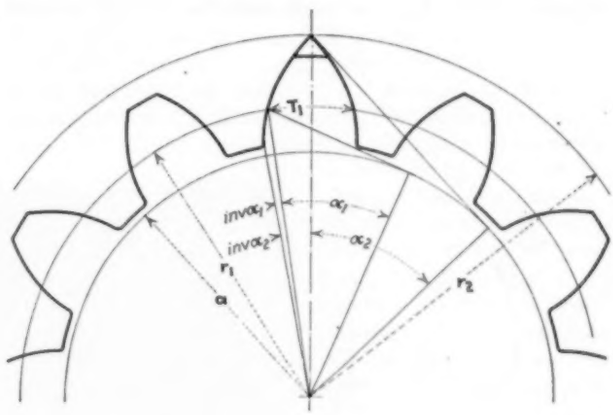


Fig. 35—Determination of the diameter at which the involute tooth becomes pointed

Table I (continued)—Values of the Involute Functions of a. Inv a = tan a − a = 0 radians

Min.	56°	57°	58°	59°
0	0.50518	0.54503	0.58804	0.63454
1	582	572	879	534
2	646	641	954	615
3	710	710	0.59028	696
4	774	779	103	777
5	838	849	178	858
6	903	918	253	939
7	967	988	328	0.64020
8	0.51032	0.55057	403	102
9	096	127	479	183
10	161	197	554	265
11	0.51226	0.55267	0.59630	0.64346
12	291	337	705	428
13	356	407	781	510
14	421	477	857	592
15	486	547	933	674
16	551	618	0.60009	756
17	616	688	085	839
18	682	759	161	921
19	747	829	237	0.65004
20	813	900	314	086
21	0.51878	0.55971	0.60390	0.65169
22	944	0.56042	467	252
23	0.52010	113	544	335
24	076	184	620	418
25	141	255	697	501
26	207	326	774	585
27	274	398	851	668
28	340	469	929	752
29	406	541	0.61006	835
30	472	612	083	919
31	0.52539	0.56684	0.61161	0.66003
32	605	756	239	087
33	672	828	316	171
34	739	900	394	255
35	805	972	472	340
36	872	0.57044	550	424
37	939	116	628	509
38	0.53006	188	706	593
39	073	261	785	678
40	141	333	863	763
41	0.53208	0.57406	0.61942	0.66848
42	275	479	0.62020	933
43	343	552	099	0.67019
44	410	625	178	104
45	478	698	257	189
46	546	771	336	275
47	613	844	415	361
48	681	917	494	447
49	749	991	574	532
50	817	0.58064	653	618
51	0.53885	0.58138	0.62733	0.67705
52	954	211	812	791
53	0.54022	285	892	877
54	090	359	972	964
55	159	433	0.63052	0.68050
56	228	507	132	137
57	296	581	212	224
58	365	656	293	311
59	434	730	373	398
60	0.54503	0.58804	0.63454	0.68485

Thus to determine the center distance between a pair of mating gears with known tooth thicknesses, equations (43) and (44) would be solved in the order given. As an example, let

$r_1 = 2.0000$ in. $\quad R_1 = 3.0000$ in.
$t_1 = 0.2850$ in. $\quad T_1 = 0.2700$ in.
$\alpha_1 = 20$ deg.
$n = 24$ teeth $\quad N = 36$ teeth
$C_1 = 5.0000$ in.

From equation (43) we have

$$\text{inv}\,\alpha_2 = \frac{24(0.2850 + 0.2700) - 4\pi}{4(24 + 36)} + 0.014904$$
$$= 0.01804 \text{ radians.}$$

From the table of involute functions we get

$\alpha_2 = 21°-16'-5''$, whence $\cos\alpha_2 = 0.93189$

From equation (44) we get

$$C_2 = \frac{5 \times 0.93969}{0.93189} = 5.0418 \text{ in.}$$

PROBLEM 9—

Given the tooth thickness of a pair of similar mating gears, to determine the center distance at which they will mesh tightly.

This problem is a simplified example of the preceding one, and the same symbols and Fig. 36 will be used.

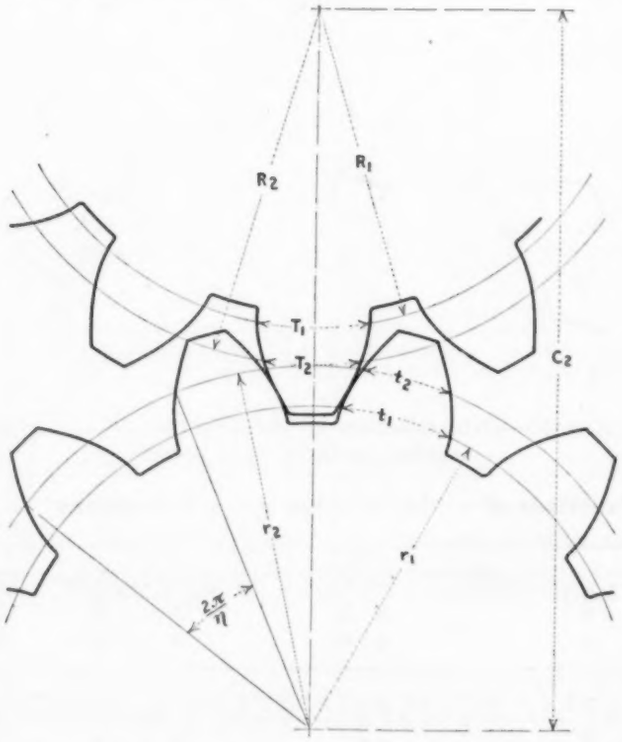


Fig. 36—Determination of the center distance for tight-meshing involute gears

The necessary equations can be derived from the preceding equations (43) and (44) by making the values on both gears identical. Whence from equation (43) we get

$$\text{inv}\,\alpha_2 = \frac{2(nt_1 - \pi r_1)}{4nr_1} + \text{inv}\,\alpha_1 = \frac{nt_1 - \pi r_1}{2nr_1}$$
$$+ \text{inv}\,\alpha_1 = \frac{t_1}{2r_1} - \frac{\pi}{2n} + \text{inv}\,\alpha_1 \qquad (45)$$

$C_1 = 2r_1$ and $C_2 = 2r_2$

$$C_2 = \frac{C_1 \cos\alpha_1}{\cos\alpha_2} \qquad (46)$$

Thus, to determine the center distance between a pair of similar gears with known tooth thickness, equations (45) and (46) would be solved in the order given. As an example, let

$r_1 = 2.0000$ in.
$t_1 = 0.2850$ in.
$\alpha_1 = 20$ deg.
$n = 24$ teeth
$C_1 = 4.0000$ in.

From Equation (45) we have

$$\text{inv}\,\alpha_2 = \frac{0.2850}{4.0000} - \frac{3.1416}{48} + 0.014904 = 0.020704 \text{ radians.}$$

From the table of involute functions we get

$\alpha_2 = 22°-13'-33''$, whence $\cos\alpha_2 = 0.92570$

From equation (46) we get

$$C_2 = \frac{4 \times 0.93969}{0.92570} = 4.0604 \text{ in.}$$

(To be continued)

Where Schools Can Help—Discussion

BY LAWRENCE F. SWENSON

We hear and read a good deal nowadays about the shortage of good machinists, but does industry really want this class of men? A good machinist, in my estimation, is a man who can do a creditable job on any of the ordinary machine tools, read a drawing and use a micrometer without spending all day doing it.

The present tendency, as we all know, is towards the highly-specialized workman. These men we have in large numbers, men who are skilled and capable of operating one type of machine. Shops having modern production systems have very little use for the all-around mechanics. In such shops all the work is carefully routed, tool lists are supplied, and every detail is arranged in advance, making the actual need of skilled mechanics very small.

On page 256, Vol. 64, of the *American Machinist* there was an editorial under the title given above, stressing the need of more mechanics. There was also a small item at the bottom of page 243 in the same issue, referring to the trade-school machinist. The editorial tells about a plan being worked out in Cleveland by Dr. Vinson, whereby the student mechanics will be given their preliminary training in some kind of a school, and the finishing touches in the shops. This plan sounds very good, but has one difficulty that is hard to overcome. Assume that a man learns the trade by this method and goes into a modern shop to work. Here he may find, as is often the case, that his wages are very little, if any, higher than the ordinary machine operator. He is then going to feel that the school time without pay, and the apprenticeship period with very small pay, were poor investments. This condition is one of the fundamental causes of the dying out of the apprenticeship system and the lack of skilled mechanics.

The article states that very few believe that a full-fledged mechanic can be developed in a trade school. A trade school has certain handicaps that make it almost impossible to turn out a first-class mechanic. One of the handicaps is the short time allotted to actual shop work, being as a rule only 4,000 hr. or about 20 months. Another is the danger of being charged with exploitation of boy labor if the work is pushed at a rate approaching that of production shops. These two conditions are sufficient to make the trade schools, at their best, places to get a boy started properly, but never places for developing first-class, all-around machinists.

Odd Jobs in a Chicago Railway Shop

By Frank W. Curtis
Western Editor, *American Machinist*

Boring stuffing boxes — Work handled on turret lathe—Cutting teeth of quadrants—Expanding arbor for bull rings — Special air-operated machine

AT THE Chicago shops of the Chicago & North Western Ry. Co. may be seen many examples of practical set-ups that have been worked out to meet the production schedule of repairs with the available equipment. Among these operations is the method of boring and facing steam-chest stuffing-boxes on a Niles 90-in. radial drilling machine, shown in Fig. 1. The jig, fastened to the table of the machine, is provided with equalizing jaws that locate the work from the inside surfaces, thereby centralizing it with the spindle of the machine. The jaws are operated by the lead screw *A* having a left- and a right-hand thread. Two clamps are used to hold the work in place. The jig has a projecting arm that is provided with a pilot bushing to guide the boring and facing bar. The bar is lowered through the bushing after which the boring tool *B* is fastened into the end of the bar. The hole then is bored to size.

Upon completion of this portion of the operation the boring tool is withdrawn and removed, and the facing tool *C* is fastened into the bar as shown. This tool is used for the facing of the top portion of the work. It is necessary to pass the bar through the bushing before inserting the facing tool in place. Two smaller holes are drilled in the top face of the work, adjacent to the bored hole, at the same setting; their location is guided by the smaller bushings that may be seen next to the pilot bushing. The stuffing boxes were usually bored on a lathe or boring mill, requiring approximately 1 hr. to complete, whereas the present method permits the completion of a unit in 20 min., floor to floor time.

For the handling of small cylindrical work, a number of turret lathes are used, as shown in Fig. 2. The operation illustrated is the boring, drilling, reaming, turning and facing of the female tank-valve on a Gisholt turret lathe. The work is held in a three-jaw chuck while being machined. At *A* is shown the male portion of the valve also handled on the same machines.

The teeth of the reverse-lever quadrant are cut on the 42-in. Gould & Eberhardt gear cutter shown in Fig. 3. Three quadrants are clamped to a swinging fixture that is pivoted from a pin-bearing, mounted on an upright bracket attached to the machine. The fulcrum point may be adjusted to suit the size of quadrant being machined, so the various sizes of work can be accommodated by one fixture. Two teeth are cut at each pass of the machine after which the work fixture is indexed to the next cutting position and set by a pin that is located in the previously cut tooth. The quadrants formerly were handled on a horizontal milling machine, two teeth being cut at a time and the work being shifted after each cut. The present method has reduced the machining time 80 per cent.

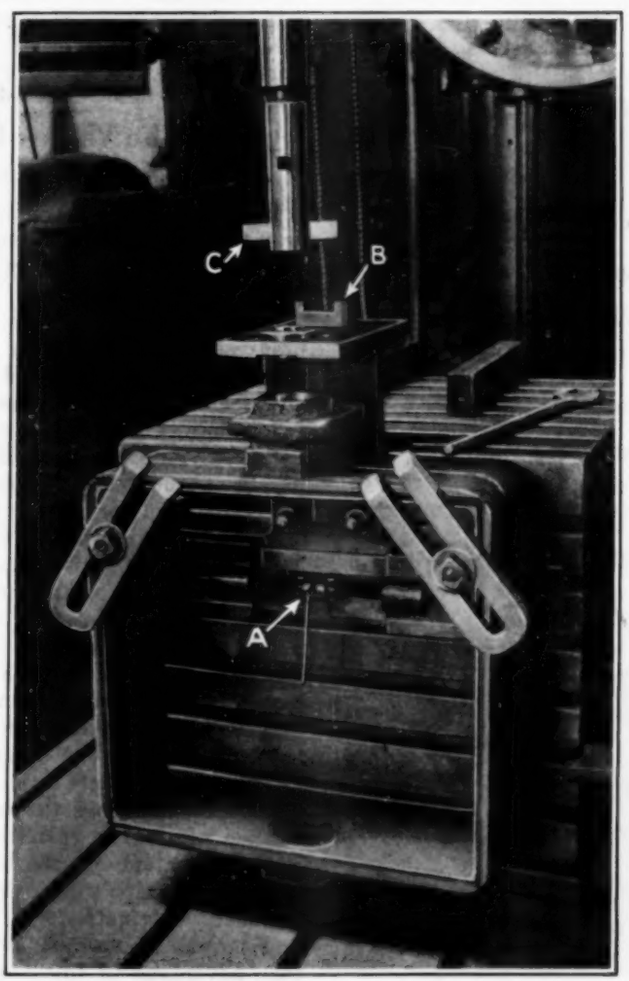


Fig. 1—Boring and facing stuffing boxes

Connecting rods are bored and faced on the two-spindle Niles-Bement-Pond boring machine shown in Fig. 4. In this operation the bushings are bored after they have been assembled into the rod, thereby insuring a true bore and avoiding the possibility of misalignment in the event that the hole in the rod is slightly out. The former method included the finishing of the bushing all over after which it was pressed into the rod, without further machining. The bushings are keyed to the rods to prevent them from turning or working loose.

The turning, facing and grooving of bull rings are handled on a 36-in. Niles-Bement-Pond lathe shown in Fig. 5. The work is centered and held by an expanding

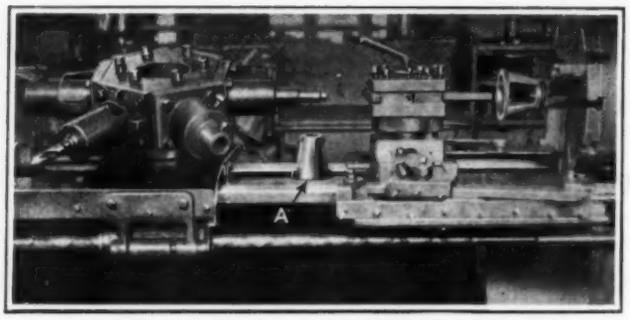


Fig. 2—Machining tank valves

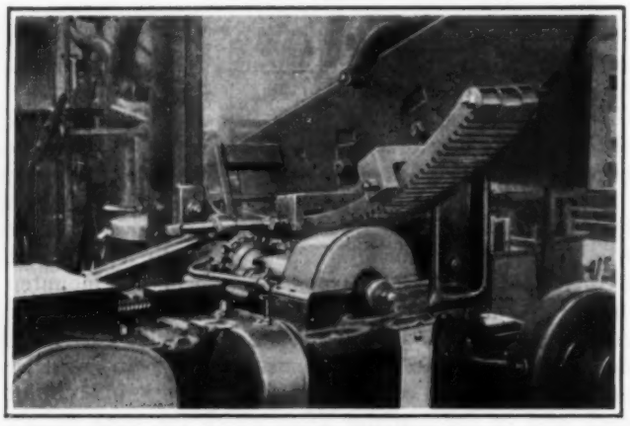


Fig. 3—Cutting teeth of quadrants

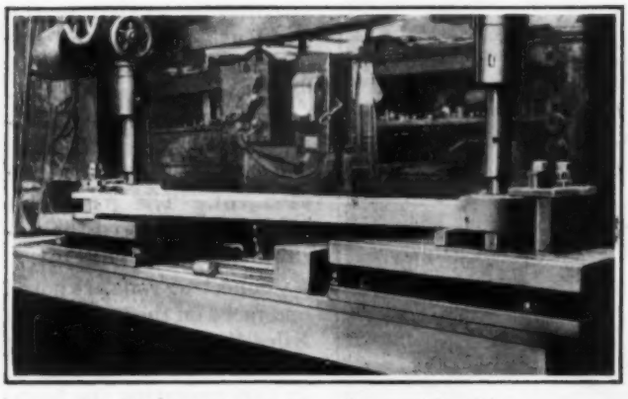


Fig. 4—Boring connecting-rod bushings

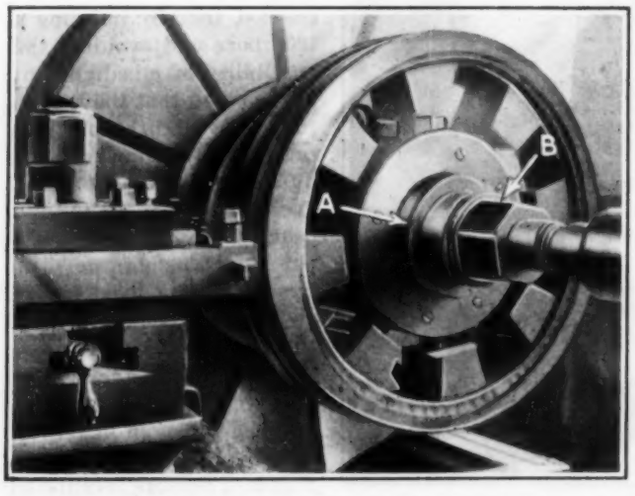


Fig. 5—Mandrel used for machining bull rings

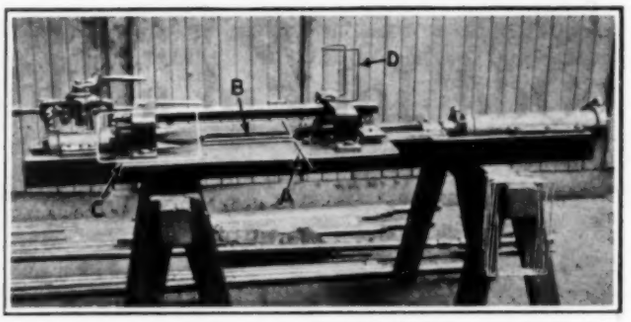


Fig. 6—Special air-operated bending machine

mandrel, provided with eight sliding jaws, that grip the work from the inside. The taper cone *A*, operated by the nut *B*, is used to expand the jaws. The bull ring is machined to suit the size of cylinder into which it fits. Two of these machines are used for this class of work.

The air-operated machine shown in Fig. 6 is home-made, and serves to make wire lock-clips that are used for locking the packing nuts of air compressors, after their adjustment. A piece of wire is cut off to the proper length and placed on the machine as shown at *A*. The right-hand cylinder then is operated to bend the wire around the center form *B*. This portion of the operation forms the wire to a U-shaped piece. The right-hand cylinder then is closed in to finish form the piece shown at *C*. The clip in this condition is passed through a set of rolls attached to a lathe, thereby forming the completed part shown at *D*. The clip is used as a safety device to prevent packing nuts from working loose.

The Value of Advertising

BY J. E. MACARTHUR

We hear on all sides, today, that no matter how good or worthy your product may be, unless it is brought forcibly to the attention of your prospects, you cannot put it across.

To make my point clear: It is the custom among all progressive manufacturers to send their foremen and some of the men connected with the engineering staffs on an annual tour of inspection to see how the other fellow does things, and a very sound policy it is.

Recently, a party was visiting a large works, studying processes and making notes, when some one became interested in a very clever machine for rough grinding castings, and, in order to secure the maker's name, the operator had actually to crawl underneath a large over-hanging portion of the grinder, and with a piece of waste wipe off the name plate, which was even then hardly legible. Another case is where a well known shaper, having the maker's name on one side only, was placed close to a large column and the operator did not even know the make, when asked.

Why not cast your name in large letters, or attach as large a name plate as space will permit? On a great many new machines the letters are either improperly cleaned or else they are loaded with filler and paint. Since inspectors are not sales managers, they are not interested in this seemingly unimportant detail.

Orders originate from many unexpected quarters, and not all from men of the old school. Therefore take advantage of this sales creator, your name plate The cost is slight; the advantages many.

The Production of Cold-Drawn Hot-Pressed Pipe Unions

By R. C. Knoll
Vice-president and Works Manager, Royal Steel Co., Chicago

Requirements for pipe unions—Class of steel employed—Dies for blanking and drawing—Hot press forging—Preserving the life of the dies

THE need of a union of the same material as butt or lap-welded pipes, in order to have the same amount of expansion and contraction, and with a brass seat to avoid corrosion, led one manufacturer to design and manufacture cold-drawn, pressed-steel unions. The design and method of manufacture were unusually good, and several millions of the unions produced were sold to the trade and gave satisfactory results. But due to the high cost from the large machine investment, the short life of tools, and the scrap of material, the process was found to be a commercial failure. Expert designers and engineers then tried to find a way to make successfully the cold-drawn union,

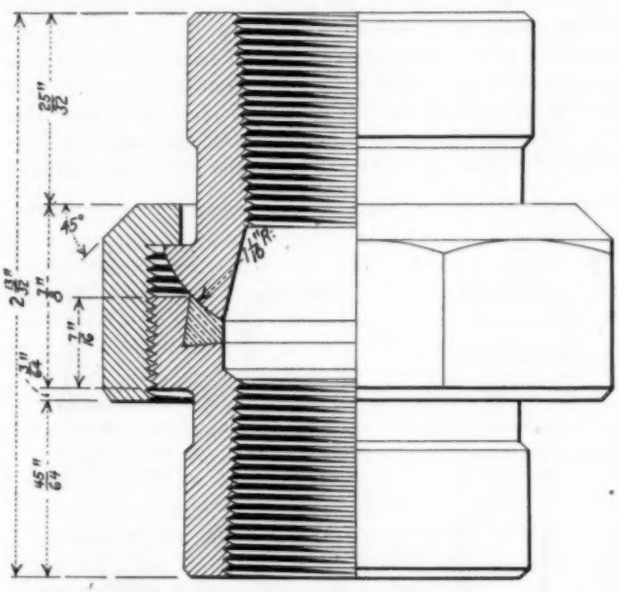


Fig. 1—Hot-pressed pipe union

but always in reducing the cost the investment was increased to such an extent that the above process had to be abandoned.

But finally a process of manufacture of cold-drawn hot-pressed unions was evolved that reduced the operations more than 50 per cent, the tools, 62 per cent, the machines, 60 per cent, the labor, 71 per cent, and the scrap to 0.1 per cent. The method reduced overhead expense, afforded a quick turn-over, and made possible the making of a superior product at a commercial profit. Cold-drawn hot-pressed forged unions, ranging in sizes from ¼ to 3 in., can be made by this process although sizes larger than these are impractical.

The methods described are for the making of 1-in. unions, shown in Fig. 1, the same process being applied to all sizes. Fig. 2 shows the sequence of operations required for making the nut from low-carbon skelp, including the blanking and drawing, punching of the center, hot-pressed forging, and the finished operations. Fig. 3 illustrates the operations for the male end, including the blanking and first drawing, the second drawing and punching of the bottom, off-setting, hot forging, trimming the flash, and the finishing operations. In Fig. 4 is shown the sequence of operations for making the female end, including the blanking and drawing, the second drawing, drawing and punching the bottom, off-setting, hot-pressed forging, and the finishing operations.

A steel having an analysis of 0.08-0.15 carbon, 0.30-0.50 manganese, 0.05 phos., and 0.05 sulphur, plain hot-rolled, open-hearth, was found to give satisfactory results, whereas the previous cold-drawn process required a special grade of full-pickled, cold-rolled steel.

The Pickling Process

In pickling hot-rolled steel, the usual process is to submerge the steel in a hot solution of 90 per cent water and 10 per cent sulphuric acid for approximately thirty minutes, rinse in running cold water, and dip in a weak lime solution to neutralize the acid and prevent the steel from corroding. The work should be raised and lowered in the acid bath for eight to ten minutes in order to give a uniform pickle over the entire surface of the work. In a still pickling bath the density is not uniform, and there is danger of over-pickling sections of the sheets making the steel porous, and causing it to break when drawn. The tools or steel are often blamed for this condition.

Steel should not be lubricated until it is ready for use since oil is a collector of dust which causes wear in the punches and dies. It is better to pass the sheets through a roll oiler to insure uniform lubrication. The surface of hot-rolled steel that is pickled uniformly is rough or porous, and retains the lubricant through the drawing operations.

In making the shells, shown on Fig. 2, it might be desired to blank and draw separately. The cost of tools, however, would be the same. The shells are

From a paper read at the Chicago session of the National Pressed Metal Society, Mar. 8, 1926.

blanked and drawn in one operation on a single-acting straight-sided press. The thickness of material ranges from $\frac{1}{8}$ to $\frac{5}{16}$ in., according to the size of union. A shell of sufficient depth must be made to leave the wall of the die thick enough to blank and draw without breaking. Knockouts must be made in the punch and die to prevent the piece from sticking as variations of ±0.005 to 0.007 in. in the thickness of this stock are the standard commercial tolerances of the rolling mills.

For annealing drawn shells, a rotary-type furnace with a spiral lining was found to give the best results. The shells are placed in standard-sized boxes at the

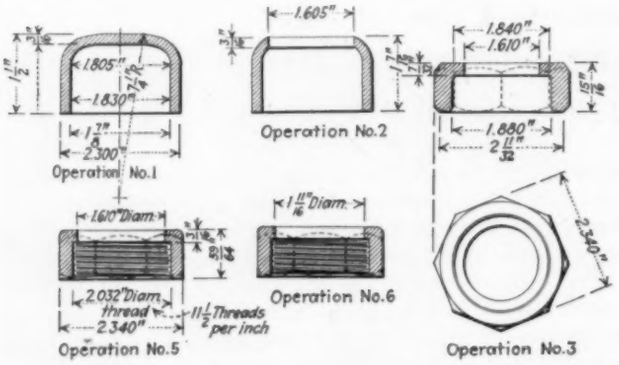


Fig. 2—Operations for making nut

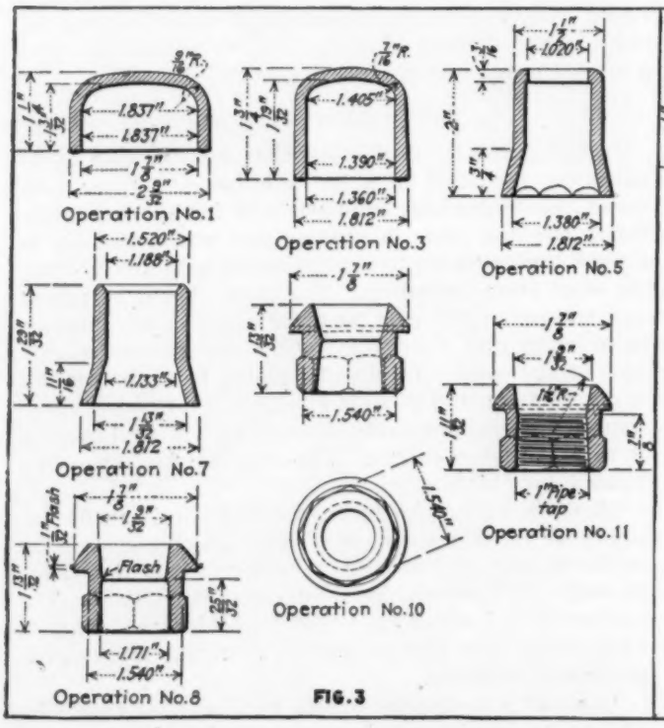
press and transported to the annealing furnace, where the box is lifted by a hoist and its contents dumped into a hopper at the rear of the furnace. The spiral in the furnace is filled over the entire length. At each revolution of the furnace the spiral collects an amount of shells equal to the amount ejected at the front end. This feature enables the operator to keep a uniform temperature of 1,400 deg. F. in the furnace. The continuous stream of shells become heated to the desired temperature when approximately three-quarters through the furnace, and soak the remaining one-quarter. The furnace is approximately 16 ft. long and 4 ft. in diameter.

A continuous conveyor, starting at the mouth of the furnace, carries the shells to a quenching bath. An elapse of time of approximately 1½ minutes from the furnace to the bath gives the best results. The quenching bath consists of ordinary soap suds, and is heated to a temperature of 125 to 150 deg. F. before it is used. The steam is shut off as soon as the stampings are placed in the bath as their heat is sufficient to keep the bath hot. The bath should never be permitted to reach the boiling point, or to drop below 150 deg. F. The stampings are held in the bath for a sufficient time to cool enough to be handled with bare hands; but no harm is done if they remain longer. The speed of the conveyor will regulate this time to suit.

When the stampings come out of the cooling bath flecked with white, they are in proper condition. If they are covered with a film of scum, the soap solution is too strong. If it is found in the succeeding press operations that the "skin," or outer surface, of the stamping is soft, while the inside is hard and brittle, it would indicate insufficient annealing.

The quenching bath is a substitute for pickling, and has proven effective because the stampings so treated are absolutely free from scale. The cleaned rough surface is desirable in the drawing operations to retain the lubricant as previously mentioned. The upkeep cost of the drawing dies has been reduced about 6 per cent by the use of this process.

A magazine feed mounted to the drawing die-shoe and connected to the ram of the press was found impractical as the shells were moved so rapidly to the die pockets that they did not set square. A dial feed with a Geneva movement is now used with good results. From 5 to 8 pockets are placed in the dial that is rotated over the die. In case the punch should break through the bottom of the shell the work slides up the punch and strikes



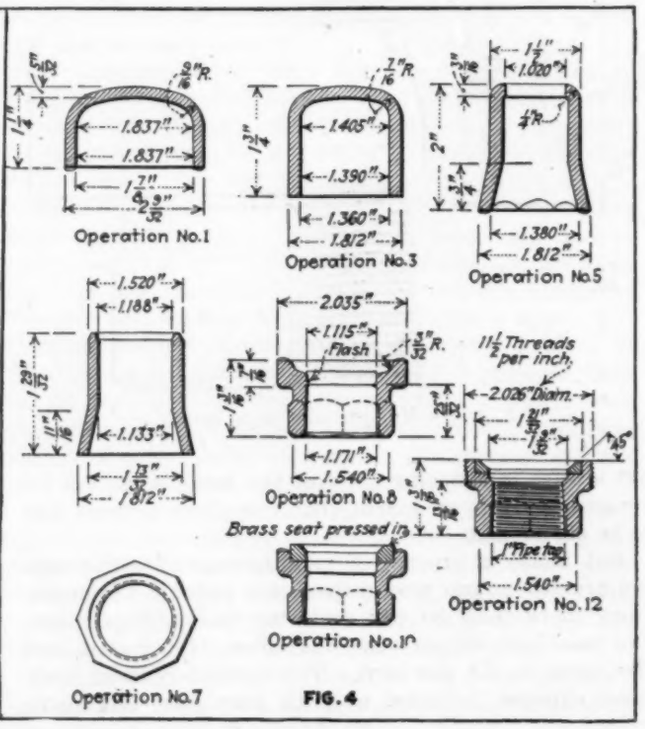


Fig. 3—Operations for making butting end. *Fig. 4—Operation for making screw end*

a safety trigger that automatically stops the indexing of the die.

A deep throat at the top of the die instead of the usual radius enables the shells to be drawn with less strain on the bottom. A die ring is placed below the draw ring, and the punch is made long and straight with an oval bottom face and the edge almost sharp. After the punch draws the shells through the die it continues and punches out the bottom. If the shells are not annealed properly, this double operation will break out the bottom before it is drawn to the proper depth. Separate operations would add to the labor cost, but might be preferred by some.

The heating of the shells for the hot-pressed forging operation requires careful attention. To get a uniform and thorough heat, with a minimum of scale and oxidation, it is necessary to use a continuous furnace with an automatic feed. The furnace used is 6 ft. long, 1 ft. wide, and 6 in. high, with openings at both ends large enough to permit shells to pass through. The furnace is equipped with a cast Nichrome plate, V-grooved in three places. The plate is placed even with the front of the furnace and extends beyond the rear opening a distance of approximately 1 ft. At this point a hopper is mounted in connection with a pusher.

The furnace uses gas as a fuel, having a small pressure blower as a separate unit. The shells are heated to a temperature of 1,200 deg. F., or a cherry red. The rear of the furnace is heated to a higher temperature than the front end to offset the effect of the cold shells entering the furnace, The shells become heated gradually and evenly and begin to "soak" when about two-thirds through. The shells drop out of the front end into a chute, at the end of which is a small metal box partly filled with graphite. The work remains in this lubricant only a few seconds, and when removed is ready for the dies.

Details of the die used for hot-press forging of the nut are shown in Fig. 5. The cast steel die-shoe and punch-holder are standard and are also used for making the other sizes of unions. The dies are fixed in the die holders, and do not slide up and down as in the dies for the other parts. The heated shell is placed on a spring pilot in the center block by an operator at the rear of the press. The operator at the front operates the press and removes the finished shell. While the operator in front is removing the work, the operator in the rear obtains another shell so that the press does not come to a complete stop.

As the ram lowers, two steel wedges *A*, mounted on the punch holder, push forward the sliding die holders *B*, a distance equal to the thickness of the wedges, at which time the two split die sections are butted together and entirely surround the heated shell. Further advancement of the ram causes the punch to enter the shell. The lowest portion of the punch goes through the hole of the shell and strikes against the spring pilot *C*, which recedes against the spring.

The second step of the punch enters the shell and comes in contact with the top of the shell, at which point the pressure on the shell begins. As the ram continues downward the length of the stroke the metal is press forged into the shape of the dies and punch. As the ram goes upward the spring pilot follows with the punch, and enters the hole in the nut. When the dies open the nut remains loose on the spring pilot until it is removed by hand. The die remains closed while the punch enters and leaves the forging.

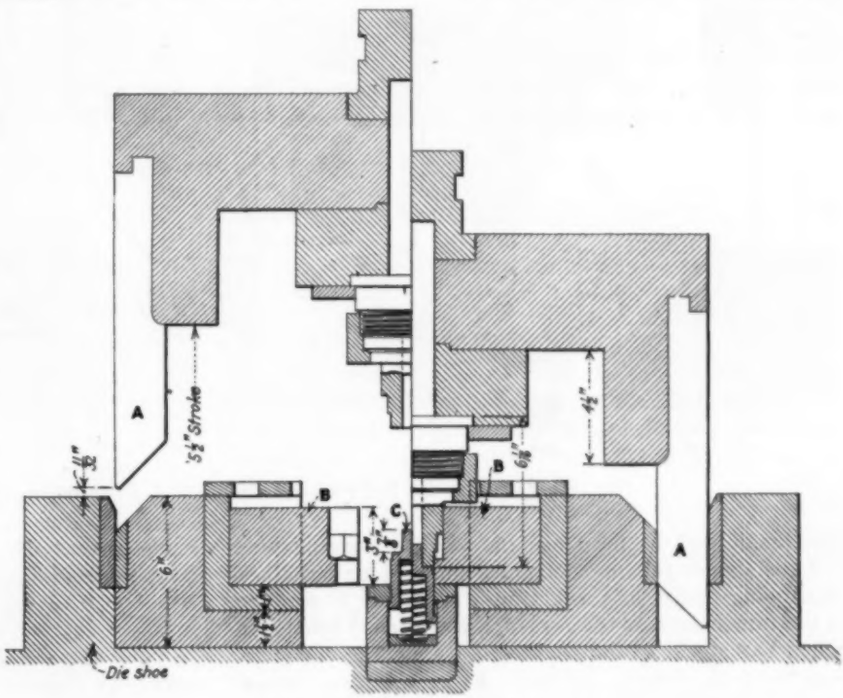


Fig. 5—Forging die for nut

In Fig. 6 is shown the assembly details of the forging tool required for making the male end. The die shoe and punch holder are the same as used for the nut, but different dies, center block, and punch are required. When the dies are opened, a heated shell is placed on the center block pilot pin. The die comes together as the ram is lowered and entirely encloses the shell, after which the spring pilot enters the shell, striking against the center block pilot pin. As the ram continues to advance, the punch centers the die halves and presses on the end of the shell until the shoulder of the punch strikes the top of the dies. Then the punch moves downward the die sections which are supported on coil springs. As the metal is trapped it is filled out to the shape of the impression made by the die-punch pilot pin, the center-block die ring, and center-block pilot pin. As the ram moves upward the punch and pin move out of the completed shell, the die opens, and the forging remains on the center-block pilot pin. Occasionally the forging sticks, but a stripper on the center block removes it. A small recess at the largest diameter of the die head allows excess metal to flash out. The flash is trimmed off afterwards in a die.

Details of the forging die for making the female end is shown in Fig. 7. The method is the same as used on the male end. In both cases the dies are mounted on springs and the two pushers are mounted on the punch holder in order to insure an even movement of the dies.

The usual handbook method of determining blank

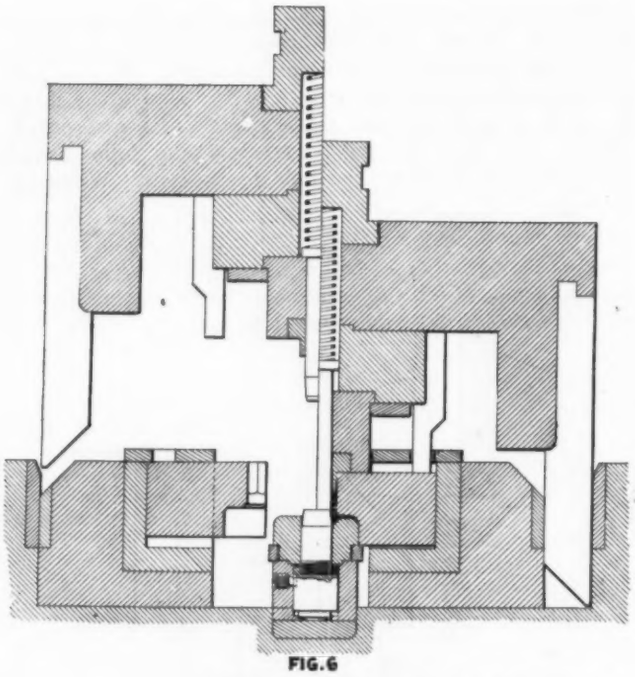


Fig. 6—Forging die for butting end.

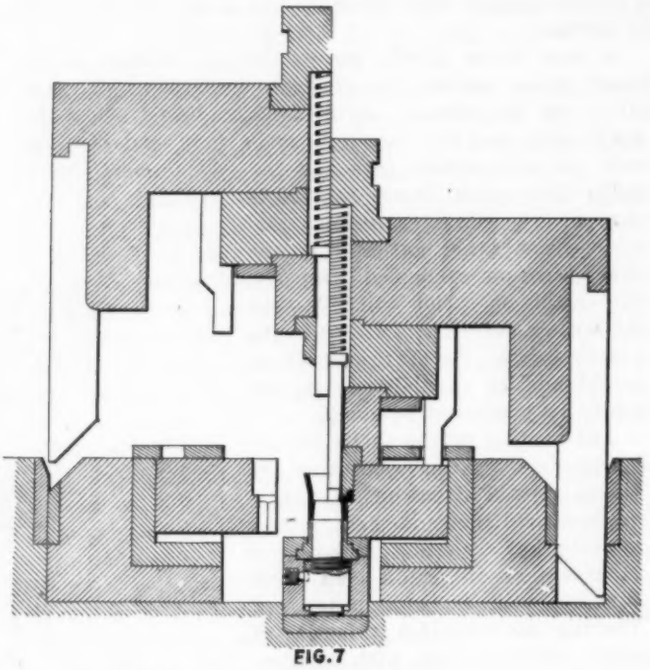


Fig. 7—Forging die for screw end

sizes could not be used on this work. Forging sizes and tools were calculated from a finished union, allowance being made for machining. A sample to conform to the dimensions of the forgings was turned from cold-rolled bar stock, to the weight of which was added the weight of the bottom cut out. From this total weight the blank diameter was figured.

Valve seats, made of a special analysis of brass, are cast, dipped in nitric acid, rinsed in water, and cold pressed to size. The cold pressing gives correct size and closes all porous spots.

It is important that the steel of the forging tools be made as uniform in thickness as possible. The support in the center block, the punch, and the pilot pins above a size of 1 in., are made with a hole in the center to give uniform expansion and contraction of the metal when in contact with the heated shell. An air blast is so arranged that on the up stroke of the press the air is turned on, cooling the tools and cleaning the surfaces of scale. The life of the dies varies between 40,000 and 50,000 forgings before they are redressed. The dies are designed so that they may be rebored to the next largest size, and thus give a total life of about 500,000 pieces.

A Comparison of Drawing Methods

BY ENTROPY

WITHIN the past week I have been in two shops that seem to be extreme opposites in their ideas of what belongs on a drawing for the use of the shop.

The first one, a fair-sized shop, puts on the drawings everything that anybody could possibly use, and then adds innumerable written or printed notes as what to do about this, that, and the other thing. On the other hand the second shop sends out to the production department drawings which barely show what the workman in that department has to know in order to do his part of the work. If the part is a casting, a full-size dimensioned drawing is made on manila paper. If it is a forging, the same thing is done and then finish marks are added. Then a drawing is made of each part dimensioned only as to finished surfaces, with whatever tolerances are to be allowed marked thereon. This drawing is all that goes into the machine shop.

There is no doubt but that the second plan saves some money in the drafting room for that particular machine. These drawings are not very helpful, however, to the designers who are called upon to create new machines or to change details of the old ones, because there are so many dimensions that can only be obtained approximately by scaling. No attempt is made to preserve the paper drawings made for the pattern shop. But this particular shop abhors what they call "patched-up" designs. Their belief is that a new machine should bear no relationship to an old one.

The first shop, on the other hand, is constantly making new designs which are new combinations of standard parts, with the very minimum of parts which are special to the new assembly. The result is that whenever a designer has a job put before him, he outlines what he wants and then goes on a hunt through the drawings for the details that he can put together.

Both plans have their merits. Many foremen in this first shop copy off details from these drawings freehand and give them to their men to use instead of the blueprints. By so doing they can omit a great deal of data which no one in the shop cares about once the patterns are made. Why not combine these two systems? Let the draftsmen make these ultra-complete details for their own use and then make other tracings leaving out the extraneous detail. Blue prints from the latter could be sent into the shop, and the first, or master prints could be kept in the drawing room.

Ideas from Practical Men

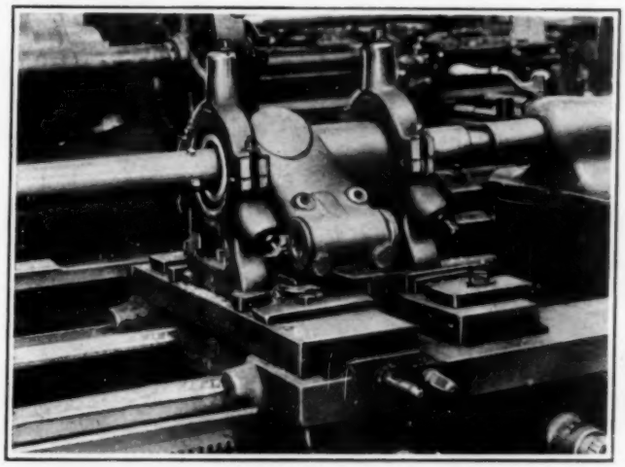
The department, "Ideas from Practical Men," is devoted to the exchange of information on methods useful to the machinery industries. Its scope includes all divisions of the machine building industry, from drafting room to shipping platform. Descriptions of methods or devices that have proved their value are carefully considered, and those published are paid for. The rates are from five dollars upward, according to their merit

Boring Work in Steadyrests

BY HERBERT F. CRAWFORD

A somewhat unusual use of steadyrests in lathe work is shown herewith. The casting shown is to be bored and is awkward to swing in any sort of a chuck. So the toolblock was removed from the carriage and two pieces of channel steel put across to support a pair of steadyrests that held the work central with the lathe spindle and in position for boring.

A fly cutter was put in the long bar shown, the bar put through the casting and held between the lathe



Boring work in steadyrests

centers. By feeding the work over the bar the cutter bores the hole, using the regular carriage feed. The cutter was adjusted between cuts, until the proper diameter was reached. This method of holding was easier than by ordinary blocking. In fact, on work of this general shape, the steadyrest has a number of advantages. The work was done in the shops of the Holt Co., Stockton, California.

A Use for Jig Bushings

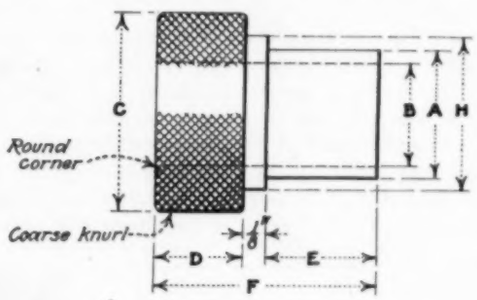
BY GEORGE W. JAGER

The practice in most shops when putting bearings and brackets on machines, where they must be in line with another part, and are therefore located on the job at erection, is usually to clamp the bearing or bracket into place, spot the holes to be tapped with a drill the size of the bolt holes in the bracket, using the bracket as a jig. After spotting, change the drills and drill the holes with a tap drill of the proper size, then tap the holes.

A much better scheme is to have a few jig bushings as shown in the accompanying table, then, after the bracket is clamped into place instead of spotting with regular drill and changing to a tap drill, insert bushings of the desired size into the bolt holes in the bracket, and drill with the regular tap drill, this method does away with constantly changing drills, also locates and drills the holes to be tapped, more accurately, thus insuring better tapped holes.

The bushings are not expensive and can be used with electric or air-operated drills, as well as with a ratchet drill and old man. There are also occasions where the bushings may be used to advantage when transferring holes and using a regular drill press.

It must be understood, however, that the dimensions shown in the table can be changed to suit individual requirements. Some shops prefer the dimension *A* to equal regular drill size, depending on drill cutting slightly larger, thus giving a small clearance. Other



Bolt Size	A	B	C	D	E	F	H
3/8	3/8	5/16	1	3/8	1/2	1	3/4
1/2	1/2	15/32	1	3/8	5/8	1 1/8	3/4
5/8	5/8	33/64	1	1/2	5/8	1 1/4	3/4
3/4	3/4	5/8	1 1/8	1/2	5/8	1 1/4	7/8
7/8	7/8	47/64	1 1/4	1/2	7/8	1 1/2	1
1	1	27/32	1 1/2	1/2	7/8	1 1/2	1 1/4
1 1/8	1 1/8	61/64	1 3/4	5/8	1	1 3/4	1 1/2
1 1/4	1 1/4	1 5/64	2	5/8	1 1/4	2	1 3/4

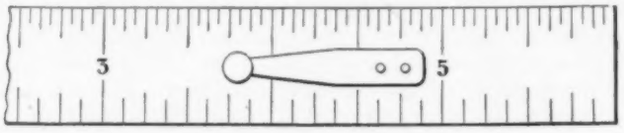
Slip bushings and table of sizes

shops prefer dimension *A* to equal, regular drill size, plus $\frac{1}{64}$ in. Still others prefer *A* to equal regular drill size, plug $\frac{1}{64}$ in. In any case *A* should be a running fit, that is a fit that will allow the bushing to be inserted and removed by hand. If, when drilling, the bushing can be turned by hand, it shows there is no bind.

Retaining Clip for a Scale

By John I. Blair

I have noticed some very ingenious and practical ideas from time to time in the "Ideas from Practical Men," and am submitting a little sketch herewith which is self-explanatory. As foreman of a good-sized machine shop, a 6-in. scale is an indispensable part of my equipment and is usually carried in my vest pocket.



Scale with clip attached

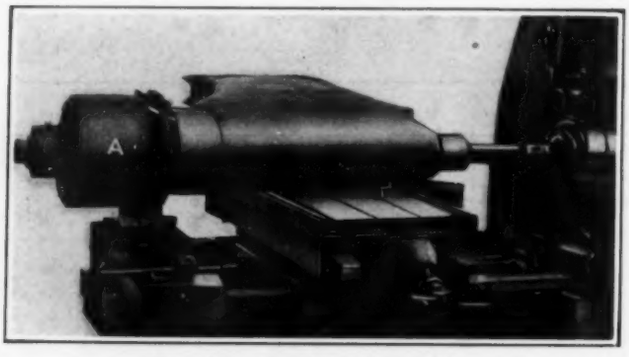
After having it drop into casting bins and on the floor, losing it several times, I hit upon the idea of fastening to it a spring clip such as is used on Eversharp pencils or fountain pens, and am much pleased with the result. The clip may be fastened with a drop of solder, or two small rivets.

Turning an Awkward Piece on a Boring Machine

By Chester H. Franklin

The head of a large special drilling machine had to be bored and turned. It was too large for any lathe, in addition to being an awkward piece to swing in any case. So it was decided to both bore and turn in on the boring machine and at the same setting.

The head was lined up on the table and bolted into position as shown. After boring, the head *A* was made to go on the end of a bar after it had been run through



Turning in a boring machine

the casting, using the bored hole as a guide. The head *A* is hollow and carries turning tools at the right, so that the outside of the casting was turned by feeding the bar toward the head of the machine. The correct diameter was secured by adjusting the cutters in the turning head.

Keeping Oilstones in Condition

By Frank W. Faulhaber

To obtain the best results from oilstones they should be kept in a good grade of machine oil in a tin container, fitted with a cover. For the larger stones a large tobacco can with a removable cover will prove useful; in the case of smaller stones a flat tobacco tin will serve.

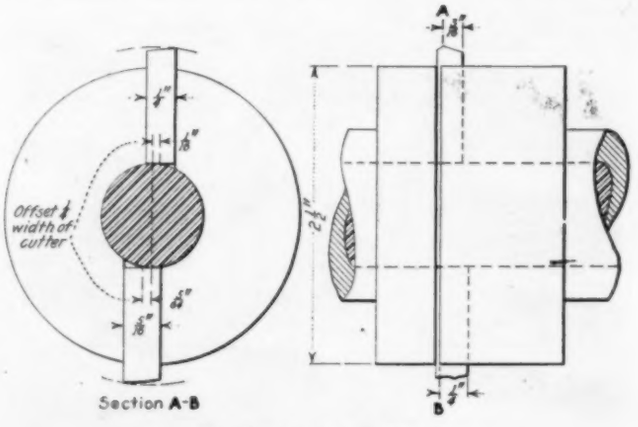
Keeping the stones under cover when not in use keeps out the dust and other objectionable foreign matter and gives the oil a chance to permeate the stones, thus keeping them always in good clean condition.

Particularly, as regards the smaller oilstones, it is wise to keep a few extra ones of different sizes and shapes on hand, because if you break one there is always another in readiness. The difference in size and shape will allow you to select the one most convenient for the sharpening job in hand.

Holders for Fly Cutters

By W. G. Aulmann

For several years I have had in use holders for fly cutters like the one shown in the sketch. The collars are about 2½ in. in diameter and the slots are offset one-quarter of their width, enabling me to turn or grind



Holder for fly cutters

the cutters radially, and then by reversing them in the slots they have the proper clearance to cut smoothly, and leave the surface without the chatter marks ordinarily left by fly cutters.

I have found ¼ and $\frac{5}{16}$ in. good sizes of cutters to use, and by making the slots ¼x$\frac{5}{16}$ in. and $\frac{5}{16}$x¼ in., respectively, I have the choice of two sizes of toolbits. By putting a piece of cold-rolled steel in the slot opposite the cutter when I turn or grind it, I am able to determine the radius or sweep of the cutter, by using a micrometer. This method has the added advantage of allowing the collars to clamp evenly.

By making and setting the cutters as described, the error in both form and radius is so slight as to be negligible, and being definite, it is easy to correct in tools that are made from them.

The cutters are easily sharpened and will not change form materially by repeated sharpening. Excellent cutters can be made of carbon steel, since they can be turned to shape before hardening, but I generally use high-speed steel toolbits and grind them to shape in the lathe, using a toolpost grinder.

Instructions for Grinding Twist Drills

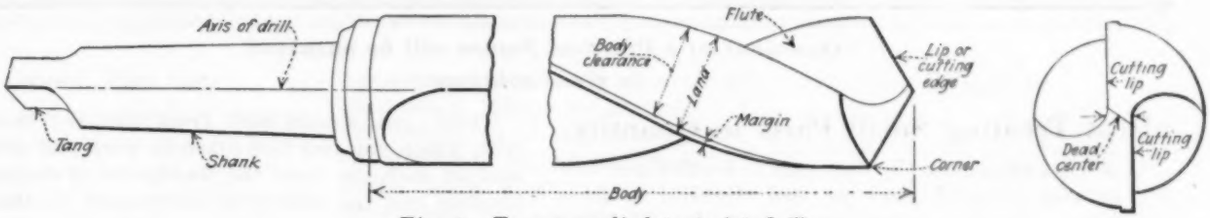


Fig. 1—Terms applied to twist drills

EFFICIENCY in drilling operations is largely dependent on a correctly ground drill. A modern drilling machine and the proper applications of speeds and feeds are important factors, but if the twist drill is not ground correctly it is natural to expect unsatisfactory results. There are no standard instructions that can be applied to the drilling of different materials, as each requires a characteristic grind.

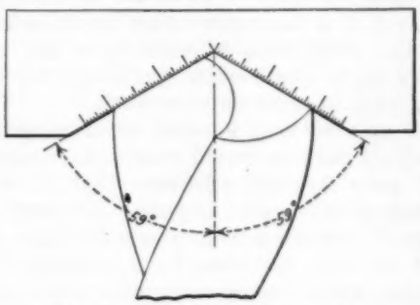


Fig. 2—Gage used for angle

Twist drills should be ground so that both lips have the same angle, and are of equal length. In Fig. 2 is shown a gage often used for checking the point, angle, and length of lip. An angle of 59 deg. is recommended for general work. If one lip is ground to 59 deg. and the other to 61 deg., the latter will have to do all the cutting.

Lip clearance, or the relief given the cutting edges, is important to insure proper penetration without interference. Approximate lip clearance may be checked by use of a small square as illustrated in Fig. 3. The angle of lip clearance should be increased gradually as the center of the drill is approached, until the line across the center of the drill stands at an angle with the cutting edges of about 135 deg. as shown in Fig. 4 at *A*.

The web separating the flutes is the supporting section of the drill. It increases in thickness slightly towards the shank, giving the drill additional rigidity. The thickening of the web decreases the flute area, therefore, as the drill is used it is necessary to compensate for the increased thickness by "thinning the point." At *B* is shown the shape of the web near the shank. To thin the point is a delicate operation. A round-face abrasive wheel should be used, forming the point as shown at *C*.

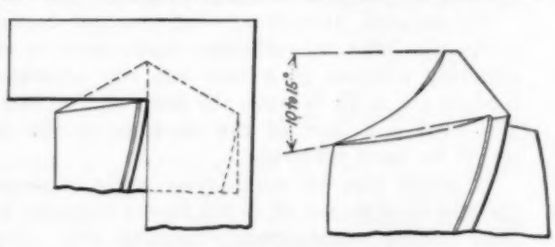


Fig. 3—Checking clearance angle

When both of the lips are ground to an equal angle but vary in their lengths, the hole produced will be oversized such as shown in Fig. 5 at *A*. If the angles of the lips are different the result will be that one lip will do most of the work, producing a hole as shown at *B*. A combination of these conditions, unequal lips and different angles, produces the hole shown at *C*.

Drills should be operated at correct speeds and feeds to produce the best results. When the point is ground correctly and the drill burns at the outer edges, as shown in Fig. 6 at *A*, or if the point "mushrooms," or turns over, as at *B*, the cause may generally be traced to excessive speed.

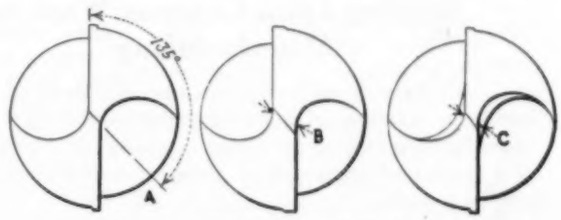


Fig. 4—Thinning point of drill

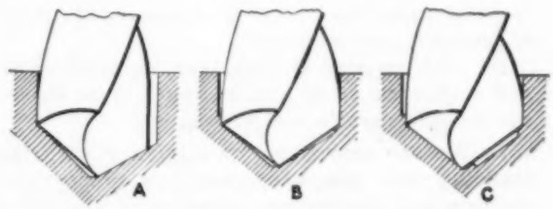


Fig. 5—Results of improper grinding

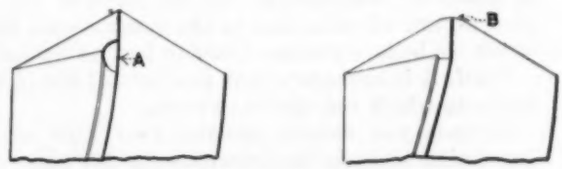


Fig. 6—Results of incorrect speeds and feeds

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Practical Shop Problems

Questions of a Practical Nature will be answered in these columns

Heat Treating Small Parts in Quantity

Q. Please advise me the best way to harden and temper articles of steel, such as nail clippers, in large quantities. By large quantities I means lots of 50,000 or more.

A. We believe the best way to harden and temper articles of steel, such as nail clippers, in large quantities, is to use a heat-treating furnace with a vibrating hearth and an automatic quenching arrangement.

The vibrating hearth feeds the steel parts into and through the furnace, spreads them out at the same time and delivers them at the end into the quenching tank. Due to this very even-spreading effect on the work as it proceeds through the furnace the heat is kept uniform within very close limits.

There may be other types of heat-treating furnaces that can do the work satisfactorily, but we have seen the one that we have mentioned working to very good advantage on needles, pins and other small parts.

Shifting from Contract Work to Manufacturing

Q. We have been in the tool and die game since 1919 and have established a good reputation locally. We also manufacture two small items and now desire to extend this work and secure other items to manufacture under our own name.

We believe that we only need to find the right type of man to come in and help develop the business rather than to spend more years and time in the slow process of "learning our way out."

We shall be glad to have your suggestions on how to find such a man and how to locate those items that we can manufacture to best advantage.

A. We are answering your inquiry with the understanding that you appreciate the proportions of the problem and the corresponding small knowledge of the proper solution which can be held by any one individual or group of individuals. On the basis of our experience we are advising you in the fundamental points on which we believe you can build to best advantage.

First, it is necessary that you lay out the investment limits to which you desire to work.

Second, you should analyze your own production knowledge in order to determine on the class of work that you can undertake to the best advantage with the least additional outlay for equipment.

Having settled on the line of work, the next step is to secure as complete a list as possible of the items that would not exceed your capacity as to equipment. Your list of such items can be built around your own knowledge of the field together with the help of product indexes, several of which go into the matter in considerable detail. These indexes can be secured from your public library.

Third, you should pick from this list those items with which you feel best fitted to work and should then analyze each one from the standpoint of market opportunities and the ability of the market to absorb your output.

Your banker can be of considerable assistance in market analysis from the business side. The McGraw-Hill Market Analysis Counselors can assist you when you have specific items in mind.

Fourth, knowing the things you can make, having picked the ones you want to go ahead on, having established the fact of a favorable outlet and a safe investment and the right time to start from the business side, you are ready to advertise specifically for the type of man you want to carry on your work.

It is our opinion that general advertising of your present general purpose would result in bringing such a flood of get-rich-quick schemers that it would be virtually impossible to pick anyone who would do you material good, but we are also certain that you can secure just the man you need by advertising for him after you have made your investigation and mapped out your own course.

Grinding Steel Tubing

Q. We have a grinding operation to perform on steel tubing which ranges from 2¼ in. to 3 in. in outside diameter and from 16 in. to 64 in. in length. The wall thickness is ⅛ in. The grinding is done to remove pit marks and scratches that are left by the drawing dies.

At present we are using an emery-charged leather wheel mounted on a standard polishing stand and are holding the work between idler rollers in a trough that can be moved against the wheel.

Our principal difficulty is in the short life of the wheel and we desire to know of a set-up that will include a solid grinding wheel. The tubing is not sufficiently straight to be handled in a standard centerless grinder.

A. We believe that the solution to your problem rests in securing a grinding machine in which the grinding element can be mounted flexibly with reference to the work and thus be able to advance or retreat as the tubing rotates out of true without altering the pressure against the surface being ground.

We suggest, therefore, that you get in touch with companies who manufacture equipment in which the grinding element is a belt and the arrangement for feeding the work is much the same as that you now use. The feed is a part of the machine on the designs to which we have reference.

It might also be worth your while to secure one of the standard makes of swing frame grinders and mount your roller arrangement beneath the wheel. The grinder could then be counterbalanced to rest on the work with the proper pressure, without interfering with its ability to follow the work as it rotated within reasonable limits for out of true.

Technical Abstracts

Milling Cutters That Cut

There are innumerable instances where one is desirous of having milling cutters dead true on the cutting edges, though, as is well known by every mechanic, such a condition is very seldom encountered.

Only by using a cutter that has been ground absolutely concentric with the axis of the milling machine arbor, can one appreciate the marked difference between that and one ground in the ordinary way.

This applies, likewise, to many other things in the machine shop or tool room, and it appears that there would be plenty of scope for some manufacturer to put on the market a simple, yet sturdy, milling machine cutter grinder, designed to be quickly clamped on to any milling machine table. E. N. Davey in *Canadian Machinery and Manufacturing News*, March 11, p. 23.

Scotch Machine Tools

The machine tool trade of Scotland specializes in the heavier tools, and the home demand for these during the year has been poor, the industries in which these tools are used not working to full capacity. Overseas requirements, however, have kept the makers employed. Like other manufacturers, the Scottish machine tool makers have utilized the comparatively dull time for the development of design and have evolved new machines for bending steel and iron tubes cold, and among other things, sheet plate bending machines of great capacity. As to the future, more orders are being booked and increasing interest is shown in the designs for new tools to reduce manufacturing costs. *British Industries*, Feb. 28, p. 120.

Quantity with Quality

Manufacturing is entering into an era of quality. Quantity production has been outstanding for many years, but now in order to meet the more cautious demand, we must have production with quality. This gives a low cost and more durable commodities. The automotive industry offers a good illustration. Increased durability of automobile parts has necessitated the extensive use of hardened-steel units requiring ground surfaces to supplement the turned and milled finishes which have previously been satisfactory. However, the progressive car builders have now generally accepted the lapping of many parts as standard needed practice, and will continue with only this method of finishing when mechanically possible. Lapping actually obtains a good bearing surface prior to the using of the parts. The engineers of one of our largest automobile factories state that lapping adds 10,000 miles to the life of piston pins. C. T. Appleton in *Abrasive Industry*, April, 1926, p. 114.

Casting Bronze Gears

Aluminum bronze has been used extensively for gear blanks in some places. As a matter of fact, one company made nearly 1,000,000 gear blanks of aluminum bronze for a customer. These were made with the teeth cast in and represented about 15,000,000 lb. of alloy. These blanks were 4 lb. lighter than solid blanks for the same size gears. The chief advantage, however, lay in the great reduction in the average hobbing time per blank.

Aluminum bronze lends itself well to the die-casting process. The gears made, as mentioned above, have proved very durable. As the strength of the material is much more than that of tin bronze, the breakage of teeth is practically unknown. The fact remains, however, that the bearing qualities of aluminum bronze will not withstand the application of so high a unit pressure as tin bronze.

The above company now is producing, commercially, teeth cast in blanks made of phosphor-tin-bronze, cast in metal molds. These blanks are used in passenger car assemblies. The saving of machine time is of considerable importance, when the number of units produced per day is as large as in the automotive industry.—*The Iron Age*, March 4, p. 619.

Carburizing Difficulties

A number of automobile manufacturers recently encountered some difficulty in carburizing camshafts. The difficulty was non-uniform carburizing. Areas copper-plated would harden and those areas desired hard would remain soft. It was the opinion for some time that the copper was transferred from one portion of the shaft to another, so for the want of a better name, the trouble was called "copper migration."

After experimenting with various grades and mixtures of carburizing compounds, one company observed that those free from lead gave satisfactory results. This was investigated and a sufficient number of experiments performed to establish the conclusion definitely that the lead present in the carburizing compound will cause non-uniform carburizing of copper-plated camshafts.

The method now used for the manufacture of camshafts by this company is to forge the diameters between the cams and bearings about $\frac{1}{8}$ of an inch larger. Then, prior to carburizing, the flange is thoroughly cleaned and dipped in a water solution containing 20 per cent copper sulphate and approximately 2 per cent sulphuric acid. The flange is not allowed to remain in this solution longer than 5 to 10 seconds, because a thick plate of copper will fall off. This plates the flange, which is the only portion plated, with copper, thus preventing carburizing. The camshafts are carburized in this condition and allowed to cool in the box after the heat-treatment.

The diameters which were forged over-size are then turned down to size, removing all the carburized zone in those areas which are desired soft. The camshafts are then hardened and result in hard cams and bearings with the remainder of the shaft soft. This method has given excellent results and is more satisfactory than copper plating the entire camshaft. E. H. Stilwell in *Transactions of American Society for Steel Treating*, February, 1926, p. 323.

American Machinist

KENNETH H. CONDIT AND FRED H. COLVIN
Editors

Established 1877

The Opportunities That Lie Ahead

SOME of us can remember when the bicycle was a big factor in the output of builders of machine tools and of other shop equipment. The bicycle business developed a number of our machines and methods, such as those used in the forming of hubs from the solid bar, the swaging of spoke ends, ball bearing machinery and the like. When the industry slumped there was wailing and gnashing of teeth in many quarters.

The development of the automobile had a much greater effect on all machine shop equipment. As a result the machine building industry is much greater than before. New methods that produce parts at astonishingly low costs have resulted and are helping other industries as well.

Now that the automobile industry has ceased to expand as in years gone by and has reached a more stable position, some are becoming pessimistic in regard to industry in general. Nothing, in our opinion, could be more unnecessary or unwise. The automobile industry is here to stay for many years, changing to meet new conditions and expanding slowly instead of by leaps and bounds.

Instead of being discouraged because of changing conditions in one field, we should grasp the opportunities afforded by the expansion in others. The increase in household appliances alone has been tremendous and has made many opportunities that never before existed. Washing machines, ironers, dishwashers, sweepers, motor-driven appliances of all kinds, and radio, are only a few of the fields of opportunities now open for improvement in manufacturing methods.

Why hitch your wagon of prosperity to one particular star when the sky is full of others, even if they are not quite so spectacular?

Why American Industry Leads

DELEGATIONS from various countries come to the United States from time to time to discover how American products, turned out by workmen whose scale of living is the highest in the history of the world, can be made at prices that enable us to compete in world markets. There are several reasons, of course, but one of the most important is the one so clearly stated in the annual report of the board of directors of one of the large steel companies:

"Due to the fact that steel plant machinery is constantly being improved, both as to size and design, your corporation, as well as others engaged in similar lines, finds it advisable at times to discard perfectly good equipment solely for the reason that it has become obsolete in type, this course being necessary in order that the cost of production and the quality of product may be kept in line with the best practice in the industry. It is impossible to forecast the extent or probable cost of these improvements from year to year, but, in the aggregate, it is bound to be considerable."

The foresight that enables American business men to relplace obsolete equipment whether it is worn out or not is a big factor in their success.

Immigration—or Machinery?

STILL further evidence of the trend of the United States toward greater use of labor-saving machinery is found in a recent analysis of migration statistics by the National Industrial Conference Board. As was pointed out in the "American Machinist" when the restriction of immigration became a national policy, the inevitable result is the substitution of machines directed by skilled workers for the unskilled worker barred out by law.

For the first seven months of the 1925-1926 fiscal year the net loss of unskilled laborers is less than half what it was for the corresponding period in the preceding year but it is still a loss of over eight thousand. And there is certainly no less need for means of doing rough work. Obviously the demand for labor-saving machines must continue to increase as the country grows and as the ranks of the unskilled laborers are thinned.

Further study of migration statistics indicates that the skilled labor to operate labor-saving machinery will be available, for we show a net gain in this class of immigrant. The countries from which skilled labor comes are not filling their immigrant quotas, however. The reason is not clear, nor is it particularly important here. What is important is that machine designers and builders of machinery must keep steadily on the job to provide the equipment that must replace unskilled labor.

Unless every machine bearing your name plate gives satisfaction to the user, you have a knocker of your product where you might have a booster. It doesn't matter whether the machine was sold through your regular channels or not the knock hurts just the same. It pays to use every reasonable method to see that a machine is satisfactory to the user, who thinks only of your building the machine, not of how it was bought or sold.

Shop Equipment News

Pratt & Whitney Model B Lathe, 20-Inch

The 20-in. lathe shown in the accompanying illustration has been added to the line of model B lathes manufactured by the Pratt & Whitney Co., Division of the Niles-Bement-Pond Co., Hartford, Conn. The lathe is similar in general construction to the 16-in. and 13-in. sizes previously described, respectively, on page 342, Vol. 59, and page 826, Vol. 60 of the *American Machinist*.

The machine is designed primarily for individual motor drive. The motor is placed in a cabinet leg beneath the headstock. It is below the center of gravity so that vibration is avoided. A 7½-hp. motor is regularly furnished with push-button control and low-voltage protection. The drive may also be by means of a constant-speed single pulley belted to a line shaft.

By means of a belt the drive is carried from the motor to the main drive shaft at the rear of the machine and thence to the headstock. The feed mechanism is driven through gearing. A standard No. 6 Johnson friction clutch is provided for the machine. The clutch is operated by means of a control rod set at shoulder height and extending the length of the bed.

The geared head is of the same general design as that of the 16-in. model B lathe and is totally enclosed. Sixteen spindle speeds are provided to give a range of from 8 to 383 r.p.m. Maag gears are used in the headstock and they are ground. The back gears are located beneath the spindle. They are controlled by means of an eccentric lever which gives them a vertical movement for engaging or disengaging them. This lever is below the spindle nose.

The back gear lock acts as a gear clutch. It consists of a pair of spur gears which slide back and forth inside of two internal gears. When the spur gears are shifted to the left the back gears may be engaged and when the spur gears are shifted to the right, with the back gears out of engagement, a positive connection is formed between the spindle nose and the spindle-speed change gears. It is, therefore, possible to throw in the back gears and operate the lock by merely moving the spindle through a distance corresponding to the width of one tooth.

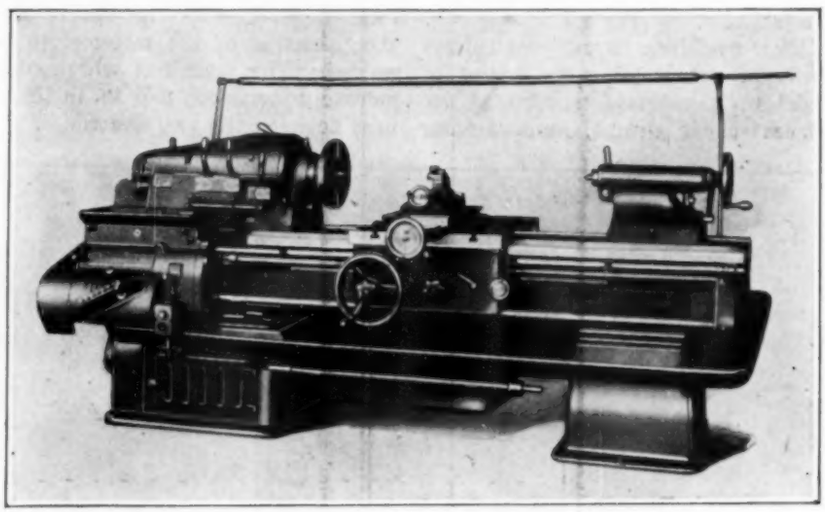
The spindle is made from alloy steel hardened and ground, and mounted in cylindrical bearings. The bearings are of brass and have taper adjustment for wear. The end thrust of the spindle is taken by hardened steel thrust washers at the rear bearing. The hole through the spindle is 2 in. in diameter. The bore of the spindle nose is for a No. 19 Jarno taper. The spindle has both flat and tapered seats in addition to the threaded portion so that accurate seating of the face plate can be secured.

A train of gears carries the power from the spindle to the feed gear box located at the front of the machine. The gear box is designed so that a rocker lever and a ratio lever work in unison with a direct-reading index plate, and any desired feed or number of threads per inch can be secured by placing these two levers in the correct relation to the plate. The range of 36 threads is from 1 to 56 pitch, while the feeds range from 0.0030 to 0.1667 for both the carriage and the cross-feeds. By combining the two power feeds a 45-deg. taper may be cut.

Both a lead screw and a feed rod are provided on the machine. A small gear-shifting device is so arranged that when the feed rod is being used the lead screw is idle and vice versa. In addition to the lead screw and the feed rod, a rod for stopping and reversing runs the length of the bed. It is so placed that it will protect the lead screw from damage from tools falling on the work.

The apron is of the standard double-wall type and is so arranged that no bevel gears are used. Spur gears and worm drives carry the longitudinal and the cross-feeds to the carriage slide. A dial allows the lead-screw nut to be easily engaged at any one of the four positions per revolution for thread chasing. This device allows the operator to withdraw the threading tool from the work and to pick it up again at any place desired.

A quick-withdrawing device, included with the machine, consists of coarse- and fine-threaded screws so arranged that either one may be engaged as desired by tightening one of two bolts. When engaged, the



Pratt & Whitney Model B Lathe, 20-Inch

Shop Equipment News

quick-withdrawing device allows the tool to be completely withdrawn from the coarsest thread by a quarter of a turn of the cross-feed handwheel. The usual stop and thread nuts are also provided. The handwheel for the compound rest is mounted at an angle to afford knuckle clearance and to facilitate reading the micrometer dial.

Splash oiling and centralized oiling are used on the machine. The headstock is flood lubricated. The lower gears of the headstock train dip into a reservoir of oil and splash the others. In addition, a geared pump supplies oil to a spreader which sprays it over the top of the entire gear train. The friction clutch also runs in oil.

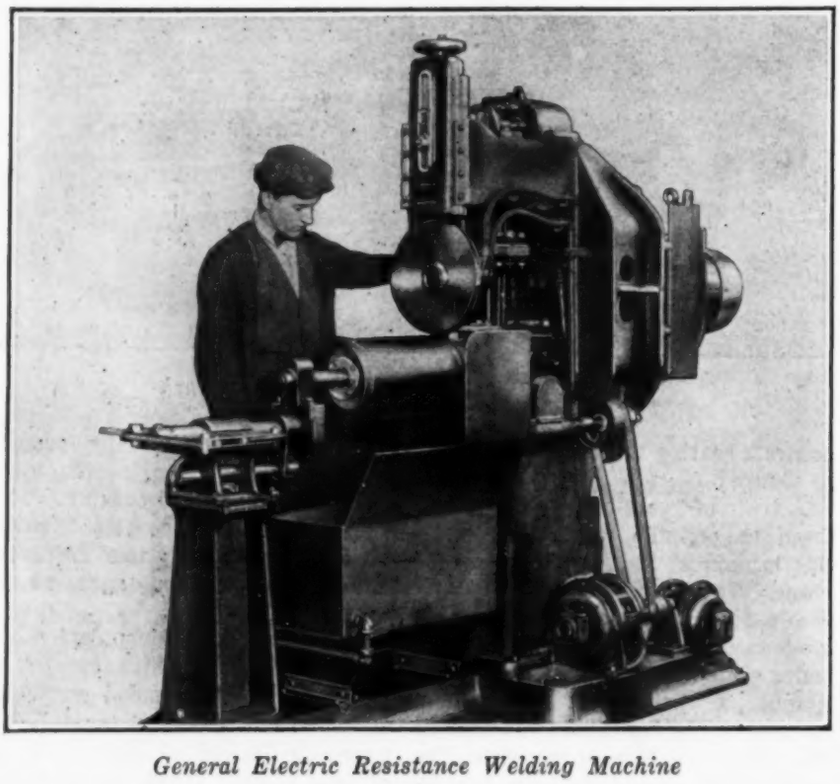
The machine is available with beds having center distances of 48, 72 or 96 in. The net weight of the 48-in. motor-driven machine, with regular equipment, is approximately 6,200 pounds.

General Electric Resistance Welding Machines

The General Electric Co., Schenectady, N. Y., has placed on the market two resistance welding machines. One is for straight-seam work, while the other which is illustrated, is for circular seams. The machines consist, fundamentally, of a frame for holding the work, a transformer for supplying current to the electrodes, movable electrode wheels and the necessary operating controls.

The machines were particularly designed for welding the seams of light metal containers such as ice cream cans, drums, and similar articles, and they are suitable only for making lap joints with relatively thin metal. Among the advantages claimed for the machines are the absence of fumes and open arcs, so that the use of masks is unnecessary, and the fact that the operator requires no special welding training.

The welding speed obtainable with the machines varies from approximately 20 in. per min. to 100 in. per min., depending on the nature and the thickness of the material to be welded. The machines will accommodate material up to ¼ in. in thickness between the two electrodes.



General Electric Resistance Welding Machine

Nugent Oil Filters

Three types of oil filters are being marketed by Wm. W. Nugent & Co., 410 Hermitage Ave., Chicago, Illinois.

The triple-bag cabinet type is illustrated in Fig. 1. It is designed to separate all foreign matter, including water, from oil. It will be noted in the photograph that the top part of the cabinet is divided into three sections. The first section is the dumping tray. The oil here passes through 2 in. of washable

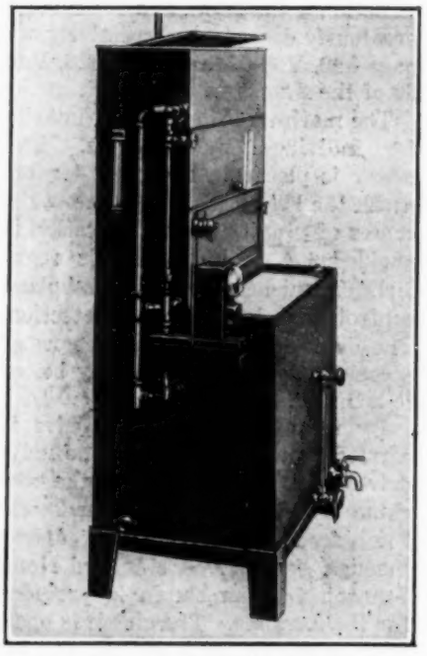


Fig. 1—Nugent Oil Filter Cabinet Type

filtering material that removes most of the heavy foreign matter, but not the water. From the dumping tray the oil flows into the second, or precipitating chamber, where the water settles to the bottom and is drawn off. The oil floats on the water and overflows through a pipe to the filtering bags which occupy the third and lowest chamber, and which extend into the storage reservoir below. Three thicknesses of filtering cloth remove all the fine grit and dust so that the oil is clean.

Provision is made to heat the oil in the top chamber by means of steam coils or by electricity. This action facilitates the separation of the foreign matter. A door in the third compartment permits an in-

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spection of the filtering bags to be made as well as their easy removal for cleaning. Should the bags become clogged with dirt so that the oil will not pass through, the oil will overflow into a trough that leads to an alarm mechanism, consisting of an electric warning bell.

The cabinet type is made in four sizes ranging in capacity from 12 to 30 gal. per hr. with filtering surfaces of 13½ and 34 sq.ft., respectively The clean oil storage is 21 gal. for the smallest and 65 gal. for the

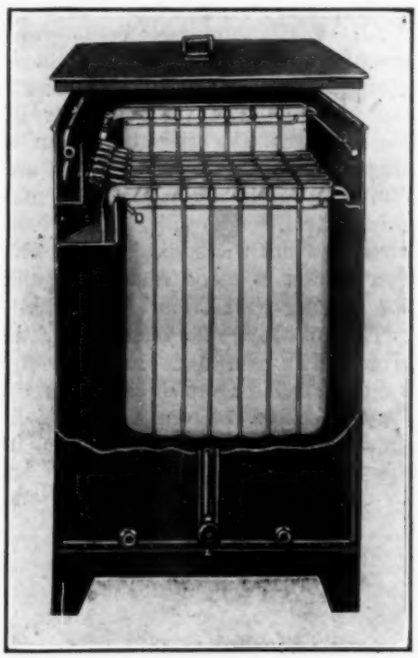


Fig. 2—Nugent Oil Filter Plain Type

largest size. The smallest size occupies a floor space of 19x23x56 in. and weighs about 125 lb., while the largest measures 25x40x56 in. and weighs about 260 pounds.

The type of filter illustrated in Fig. 2, is designed to clean any kind of lubricating or cutting oil that is free from water. As the sectional view shows, it consists of a series of filter-cloth bags suspended from a suitable rack. A steam pipe or electric coil heats the dirty oil as it enters on the left so as to reduce the viscoscity and thereby make the separation of the foreign matter rapid. The filtering process is continuous. If the flow of oil is in excess of the capacity of the filter, a part of the oil may be filtered and the rest by-passed directly into the clean-oil reservoir. This method can only be used, however, where the oil is not very dirty. The bags may be quickly removed by raising the cover and lifting the frame off the rack. They should be washed in hot soapy water or kerosene. An automatic bell-alarm notifies the operator that the bags require cleaning.

This type of filter is made in 27 sizes ranging in capacity from 40 to 2,000 gal. per hr. and employing from 1 to 40 bags. The filtering surface ranges from 7 to 336 sq.ft. The overall dimensions for the smallest size are 17x27½x46 in. It weighs about 200 pounds.

The third type is designed for marine and locomotive Diesel engines. It is similar to the second type described above, except that provision is made to prevent spilling during the rolling of a ship or the swaying of a locomotive.

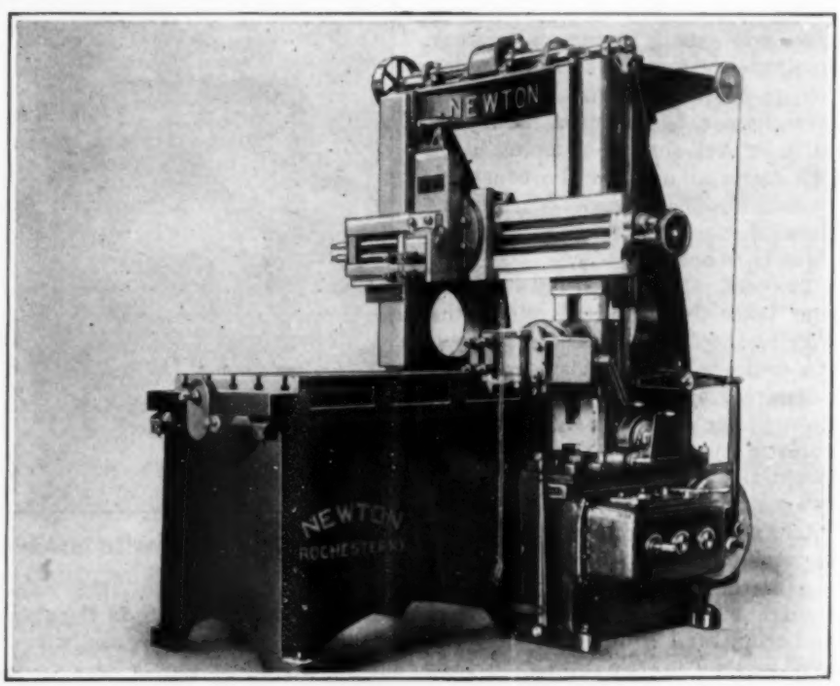
"Newton" Side-Head Crank Planer

A crank planer built in two sizes, with a side head has been added to the line of the Newton Works of the Consolidated Machine Tool Corporation of America, Rochester, N. Y. The planer, which is shown in the accompanying illustration, can be had with either a 34- or 39-in. stroke. It is similar in general principles of design to an earlier model previously described on page 943, Vol. 56 of the *American Machinist*.

The side head, provided in addition to the regular rail head, has a vertical feed and hand adjustment. If desired, each upright can be equipped with a side head. This head can be lowered below the top of the table when necessary. It has a relief tool apron with double clamps and may be swiveled 45 deg. to either side of the horizontal. It is balanced by means of a counterweight carried at the rear of the machine and clear of the operator.

The uprights of the machine are of box section and are bolted and doweled to the base. They are braced at the top by means of a deep, sectional tie beam. The cross-rail is adjusted by power through double lifting screws. It is gibbed to the uprights and clamping means have been provided. The toolslide in the vertical head has equal movement above and below the bottom of the rail to reduce the overhang. The vertical head can also be swiveled 45 deg. each way.

The base is a one-piece casting of



"Newton" Side-Head Crank Planer

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box type. It has a closed top and two surface bearings for the table. Side bearings and take-up gibs are also provided. The table is of double-plate construction and has five machined T-slots. It is provided with a chip pan at each end. Work can be positioned while the machine is stroking, by means of an adjustment block and screw. This block can be clamped during the cutting operation while the machine is running.

Six speed changes for the table stroke are provided through a gear box of the sliding type. The gears are hardened, inclosed and run in oil. The table is controlled by means of a clutch and brake, permitting "jogging" for the setting of tools. The clutch can be locked so that the machine cannot start unexpectedly and injure the operator or the work. The stroke adjustment is made from the operating side of the machine, by turning a crank handle. The length in inches of the stroke is shown by an indicator.

The machine is driven through a 10-hp., 1,200-r.p.m. motor or by means of a single pulley, through a change gear box to a helical driving gear. The driving pinion is mounted between two bearings. The driving bearings are bushed and the ones carrying a heavy load are bronze lined.

Hallden Rotary Wire-Straightening and Cutting-Off Machine, Automatic

An automatic rotary wire-straightening and cutting-off machine has been placed on the market by the Hallden Machine Co., Thomaston, Conn. The machine is intended for straightening coil wire, for cutting it into pieces of a predetermined length and for then depositing the pieces on a forked table. The machine will handle coils of various composition from brass to alloy and high-carbon steel.

The unit consists of a preliminary seven-roll straightener, a rotary straightener, two pairs of fiber pinch rolls and a flying shear. The rotary straightener is equipped with five pairs of bell-shaped crimping dies. The material used in the construction of the dies is dependent on the class of work upon which the machine is to operate.

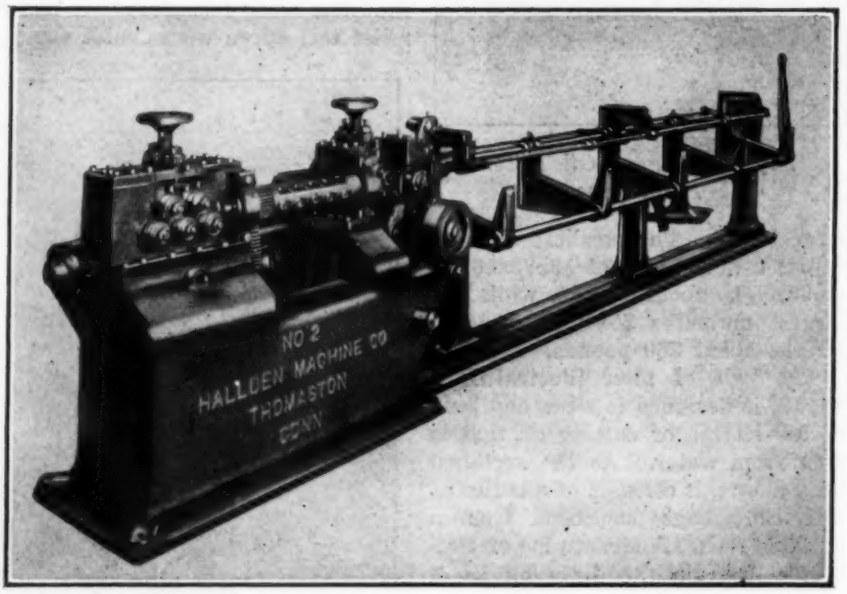
The preliminary seven-roll straightener takes the first bend out of the wire and it functions also as a feeding device. The seven grooved steel rolls are designed to carry the wire through the rotary straightener at a uniform speed without slippage between the rolls and the wire. The five pairs of crimping dies in the rotary straightener are so constructed as to allow the feed rolls to start the end of the coil of wire through the straightener when the dies are set at full crimp, and without stopping the machine. The two pairs of fiber pinch rolls between the straightener and the shear help to pull the wire through the rotary straightener. The grip of these five rolls is said to be sufficient to pull the end of the coil through the straightener without marking the wire.

The flying shear moves forward with the same speed as that of the wire and is actuated by means of a mechanism tripped by the wire. At the same instant that the shear moves forward, the gate in the shear cuts off the wire. After the wire is cut off the shear moves back to its original position. The shearing dies are of circular construction and are removable for sharpening when worn.

The tripping mechanism is of the trigger type. The wire passes under the trigger which is thereby lifted releasing a lever on a one-revolution clutch. This stopping lever is thrown out by means of a spring. The pressure required to raise the trigger is said to be small enough to prevent any bending action on the wire. The receiving tree is constructed with tipping arms to make it possible to conveniently dump the roads into a box or truck. The arms are operated by means of a lever.

All fast running parts are mounted on roller bearings and equipped with the Alemite lubricating system. The various units of the machine are operated from a single shaft. The gears, which are totally inclosed, are made from machine steel. The flier is driven directly from the main shaft. The flier pinion is made from fiber and the driving gear from alloy steel.

The machine is made in four sizes. The No. 0 is intended for handling wire from $\frac{1}{16}$ to $\frac{5}{32}$ in. in diam., the No. 1 from $\frac{1}{8}$ to $\frac{1}{4}$ in. in diam., the No. 2 from $\frac{1}{4}$ to $\frac{3}{8}$ in. in diam. and the No. 3 from $\frac{3}{8}$ to $\frac{5}{8}$ in. in diam. Motors of 5, 7½, 10, and 15 hp., are used, respectively, for the four machines. They operate at 1,800 r.p.m. and are direct connected. The weight of the machines are 3,500, 5,000, 6,500 and 9,000 lb., respectively.



Hallden Rotary Wire-Straightening and Cutting-off Machine, Automatic

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"Cleveland" Double-End Threading Machine, Model J

The model J automatic double-end threading machine, illustrated, has been added to the regular line of automatic screw machines manufactured by the Cleveland Automatic Machine Co., Cleveland, Ohio. The machine is built in two sizes and it is intended for production threading of pipes, nipples and studs or milling the bearing diameters on both ends of shafts as well as for the simultaneous drilling or chamfering of both ends.

As may be seen in the illustration, the machine is equipped with a hopper magazine manufactured by the company. The magazine is located in the center and it is provided with oscillating levers timed from the camshaft to control the dropping of the parts to sliding conveyor fingers which carry each piece to the air-operated floating center chuck.

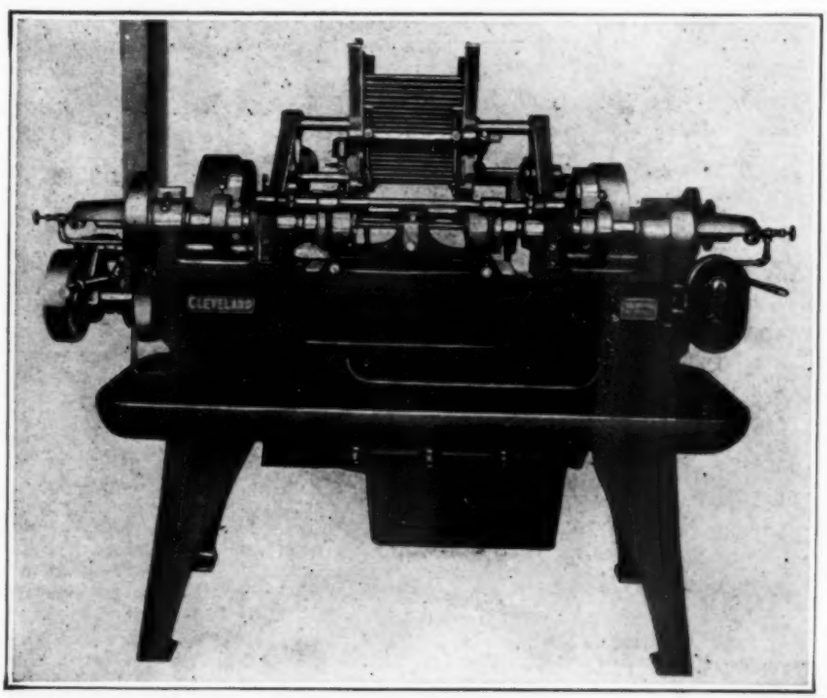
The center chuck on the model J machine holds the work stationary while the tools are rotated. Previous "Cleveland" machines have been provided with stationary tools and the work has been revolved. Although an air chuck is regularly provided, a mechanical chuck can be had.

The machine is driven by means of a single-pulley belt or a motor as desired. The power is controlled by means of a hand lever operating a clutch in the driving pulley. The engaging and disengaging of the tool feed is accomplished by means of a hand lever at the extreme right.

The feed wormgear, also at the right-hand end of the machine, is provided with a safety pin device which shears off the pin and stops the feed in case of accidental jamming of the tools. The pin is easily replaceable.

Two drums on the camshaft furnish the tool feed to the two tool spindles through cams mounted on the circumferences of the drums. Cams on the side of the tool feed drum operate the finger conveyors in the magazine. A disk on the camshaft operates the lever controlling the feed of parts to the conveyor fingers. A drum on the camshaft operates the air cylinder for opening and closing the floating center chuck. Four spindle speeds are provided for by means of change gears.

The coolant is carried through the tool spindles and the dieheads in a constant stream so that the chasers will be lubricated and the chips carried away.

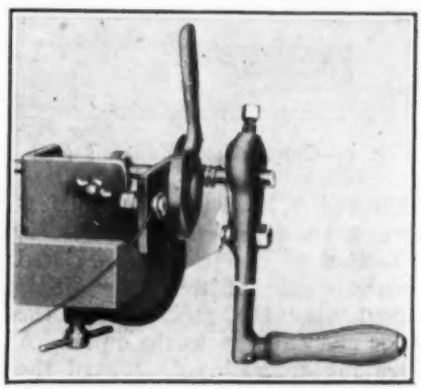


"Cleveland" Double-End Threading Machine, Model J

Fostoria Coil Spring Winder

A hand machine for winding coil springs has been placed on the market by the Fostoria Screw Co., Fostoria, Ohio. The device is designed for clamping to any workbench.

The general construction of the machine can be seen from the accompanying illustration. The size of the spring is determined by the size of the mandrel used, while the pitch or lead of the spring is determined by the setting of the cam which is adjustable in its position to produce the desired pitch.



Fostoria Coil Spring Winder

Manning, Maxwell & Moore, Inc., to Manufacture Detrick & Harvey Products

Manning, Maxwell & Moore, Inc., 100 East 42nd Street, New York, N. Y., have acquired the rights to manufacture and to sell the products of the Detrick & Harvey Machine Company.

The manufacture of the Detrick & Harvey openside, double-housing and convertible planers as well as of the floor boring, drilling and milling machines will be continued at the Putnam Works of Manning, Maxwell & Moore, Inc., located at Fitchburg, Mass. Special tools and repair parts can also be obtained.

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Connecticut Exhaust Fans

The Connecticut Blower Corporation, Hartford, Conn., has placed on the market an improved type of exhaust fan for conveying finely divided materials by means of air. The fan is illustrated in Fig. 1,

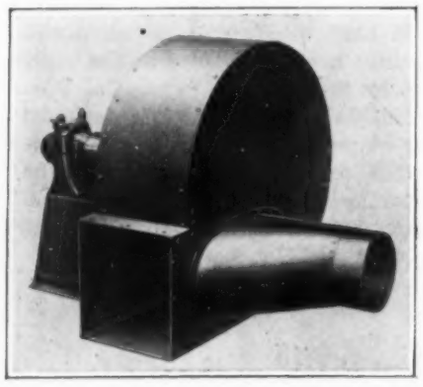


Fig. 1—Connecticut Exhaust Fan

while Fig. 2 shows the principal features of the design.

Instead of the inlet being placed at the center of the wheel, it is placed near the periphery of the rotor and adjacent to the outlet. A flare in the inlet pipe toward the discharge opening is also provided. The result is that the material conveyed by the air is discharged immediately without being passed through the wheel and around the casing. The purpose of this arrangement is to reduce the wear of the wheel and the housing and the clogging or unbalancing of the blades.

Each wheel contains 16 blades that are riveted to a steel cone and

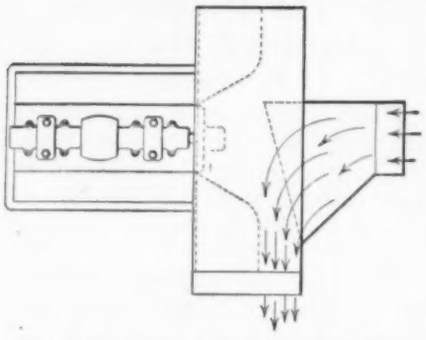


Fig. 2—Principle of operation of the fan

a heavy hub. The air set in motion by the rotor rushes past the projected suction opening and creates a suction therein and simultaneously pushes the material-laden air toward the outlet. The combined effect is sufficient to produce a pressure of 12 in. of water in the discharge pipe.

The fans are constructed almost entirely of steel. The belt-driven models are equipped with double-row, self-aligning ball bearings. Direct-connected motor types may also be obtained. The fans are made in eleven sizes, either single or double, with inlet diameters ranging from 9 to 33 in. The smallest single-rotor fan weighs 220 lb., while the largest double-rotor fan weighs 2,200 lb. The fans are reversible and the inlet and discharge connections may be arranged in various positions. The fans may be mounted on the floor or bolted to the ceiling. They will handle any material that can be conveyed by air such as sawdust, cement, powdered coal, chemicals, cereals, cotton and the like.

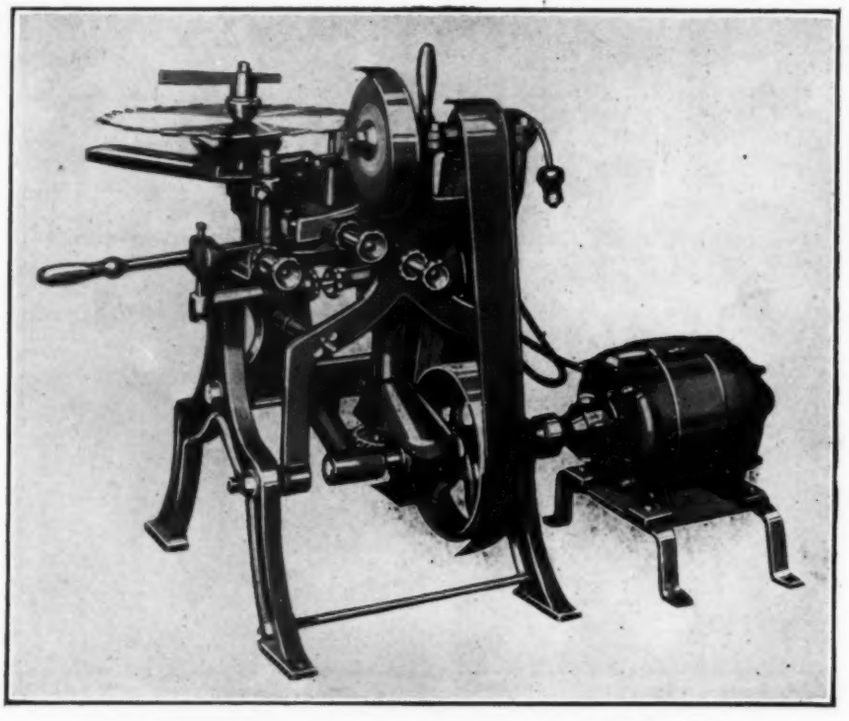
"Rogers-Buffalo" Circular Saw Sharpener, Automatic

An improved motor-driven, circular-saw sharpener has been placed on the market by Samuel C. Rogers & Co., 10-16 Lock St., Buffalo, N. Y. The machines are built in three sizes to cover a range of saws of from 6 to 72 in. in diameter.

The machine is fully automatic for saws with 4 teeth or more to the inch and with flat-faced teeth. Saws having bevel-faced teeth can be accommodated by the machine and these can be sharpened semi-automatically.

The No. 1 machine is a bench-type unit equipped with a ½-hp., single-phase motor to be operated from an ordinary lighting circuit. The motor and the machine are connected through a flexible coupling and are mounted on a table furnished with each machine. It will accommodate saws of from 6 to 40 in. in diam. The Nos. 2 and 3 machines are equipped with ½-hp., 3-phase, 60-cycle motors. The No. 2 machine will accommodate saws of from 8 to 48 in. in diam. and the No. 3 machine will handle saws 8 to 72 in. in diam. Both of the latter models are floor machines.

Three saw gumming wheels and rubber belting are supplied with each of the machines.



"Rogers-Buffalo" Circular Saw Sharpener, Automatic

News of the Week

Reo Expert Forecasts Big Improvements in Design and Manufacture of Gears

Bethune says present automobile gearing is hopeless

Decided improvements in present methods of making gears were forecast by John Bethune, gear consultant of the Reo Motor Car Co., of Lansing, Mich., in speaking before the Detroit Chapter of the Society of Automotive Engineers at the General Motors Building, March 25, on the subject "Recent Developments in Gear Design and Gear Cutting." He discussed the various types of gears, and gave it as his opinion that the next year will see a big step in advance of present methods.

"The average automobile would travel from 15 to 20 per cent further on a gallon of gasoline if it had the proper gear ratio at all times in the rear axle," said Mr. Bethune.

"By putting in a system of gearing in my car, I increased mileage 25 per cent. I consider the type of gearing which is now used in the present automobile transmission as hopeless, because of the ratios we are forced to use and the size of teeth we must use in order to transmit the power. The spur gears in the transmission today are in exactly the same position as the straight type bevels were in 1911. You know what has been done since then in bevel gears."

A Personal Test

Turning to the internal type of gear, Mr. Bethune told of his personal experience with this type. He said:

"I made up three sets of gears and put one set in my car. Another set I carried with me, and thought that I would be all ready to change gears out in the woods somewhere. I have driven that car 18,000 miles and have never been called upon to make a change. That car weighs 3,600 lb. empty. I drove it up a 17 per cent grade with five passengers and baggage, making the total weight 4,400 lb. I drove it down through Pennsylvania and West Virginia, for long distances purposely to see how these gears would work out. This gear has 17 teeth, 10-12 pitch. The mating gear, which is an internal, has 22 teeth, or a five teeth difference. Another gear, which is also part of the same assembly, has 34 teeth, and in turn runs into a 39 tooth, or five teeth difference, which gives you ¾ in. off center in both places. The arc of action is large. The gears show very little, if any wear, after having been driven 18,000 miles.

"When traveling along regularly I used a 3.9 reduction. This travels straight when road conditions permit. When I came to some hilly conditions I changed to a 5.9 to 1. If when driving with that 5.9 to 1, I throw out the clutch and unclutch this member, the tendency of the whole thing is to go around together, and you can clutch up at 45 miles an hour without any shock or jar as you let the clutch in. There is no difficulty in changing up; a little in changing down, but not nearly what you get in the ordinary transmission. I have an eight pitch in my car and have driven long distances under heavy loads and it is all right. It is the quietest transmission I have ever seen. There are so many teeth in contact that it does not get a chance to jump from one tooth to the other. I believe we should look into the possibilities of this gearing, because it may have a future.

The Hypoid Gear

"Another type of gear has been developed by the Gleason Co. I have done some recent work on that and feel satisfied that this new gearing, known as the hypoid type of gearing, is going to be the coming gearing for rear axles. In this new type of gearing, the center line of pinion, in place of intercepting the center line of gearing, is either above or below, all the way from 1½ in. to 2½ in., though there is no limit on it. Just as soon as you start to lower the pinion below the center line of gear you begin to introduce the sliding action. Your pinion also begins to increase in diameter. I have watched the machine in operation and am satisfied that there are no mechanical difficulties about getting the hypoid machine to operate successfully."

Fritz Medal Presented to E. D. Adams

The public ceremonies of the presentation of the John Fritz Gold Medal, awarded to Edward Dean Adams, engineer, scientist and financier, whose vision, courage and industry made possible at Niagara Falls the large hydro-electric power development, were held on the evening of March 30 in the Engineers' Club, New York.

Before the presentation, there was a dinner of the Board of Awards and guests, at which addresses were made by Charles F. Scott, of Yale University, L. B. Stillwell, chairman of the Engineering Foundation, and Dr. W. H. Onken, Jr., editor of *Electrical World*.

Mr. Scott brought out the fact that the history of the Niagara Falls Power Co. is the history of the pioneer of the hydro-electric system, a forerunner of the modern utility power service. It recorded, he said, the great step in the transition from mechanical to electrical power. He further stated, that the event of the nineteenth century was the great adventure of the world in power.

Mr. Stillwell made the point that there were in 1917, when we went into the war, only 20-million horsepower of power electrically generated, and that if the Niagara development had been delayed five years we would have had five million horsepower less when we needed it.

The presentation speech was made by Major Fred J. Miller, chairman of the committee which made the award. In his response Mr. Adams gave a brief history of the development of the power of Niagara Falls. Other speakers were James M. Beck and Professor Arthur Edwin Kennelly, of Harvard. Lieutenant Frank B. Jewett, chairman of the board of award, presided.

MacNider Extols Merits of Industrial Mobilization

After describing the important part that the electrical public utilities in the New York Metropolitan area are scheduled to play in the War Department's program of "industrial preparedness as an insurance against war" Colonel Hanford MacNider, assistant secretary of war, declared in an address before the New York Electrical League on March 31: "The stronger we can build up this insurance, the stronger our voice is going to be in the councils of the world," he said. "It means that we can insure ourselves against any aggression. It is a frank declaration that we want peace and that we intend to have it—insurance for peace, insurance against war."

"Our major effort is the industrial mobilization planning for emergency."

Speaking of the plan to allocate assignments for the manufacture of the vast requirements of the War Department in the event of an emergency, Colonel MacNider said: "You can see how necessary it is that we have every component that comes into that picture all co-ordinated, so that when the bell rings again, if it ever does, it will mean that the manufacturer can go to his safe, take out his contract, sign it, mail it, call in his superintendent, call in his foremen, pull out his plans, his specifications, his dies, his castings, whatever is necessary for him to have to meet his part of the program, and start to work instantaneously, should the Congress, representing the people, declare the emergency is upon us."

Conference at Purdue Extols Advantages of Electric Heat

A conference on industrial electric heating has recently closed at Purdue University, Lafayette, Ind., with the most definite result being the fact that the possibilities of electric heating in connection with industrial processes have barely been touched upon thus far, and that within the next decade the electric central stations located in industrial districts are likely to add as much electrical heating as they now have of motor load.

The conference was a project of the engineering extension department of Purdue University, with the school of electrical engineering in direct charge. The attendance of 150 represented practically every industry in Indiana and the industrial district surrounding Chicago.

The entire field of electric heating was covered in the program, by illustrated papers and by demonstration of equipment in operation, ranging from the low-temperature, automatically controlled baking oven to the very high-temperature electric arc furnace for melting brass and steel.

The principal arguments in favor of electric heat were brought out very emphatically, and many users of electric heat stated that they would continue to make use of the advantages of electric heat over other types even if the cost of other competitive fuels were eliminated.

Alloy steel and brass were melted electrically and poured before the audience and the various ovens, furnaces and melting pots were electrically operated and controlled.

At the banquet which concluded the conference over one-hundred attended, and David E. Ross, vice-president and general manager of the Ross Gear and Tool Co., of Lafayette, spoke of the moral responsibility of manufacturers of automobiles and automobile parts to provide the best materials and workmanship as the lives of careful as well as careless drivers depended thereon. The obligation of manufacturers of parts and of public utility representatives to strive for the success of their customers in producing low cost and high quality of products of all concerned was also stressed.

The most important parts of the program were considered to be the talks which dealt with testimonials by users of electric heat. A unanimous decision to continue the conference as an annual affair was indicated with further emphasis requested upon operating experiences and costs.

Regulations Drafted for Tetraethyl Gas

Tentative regulations governing the manufacture, distribution, and use of tetraethyl lead gas and suggestions for regulations covering the sanitation of garages have been submitted by Surgeon General Cummings, of the United States Public Health Service, to the health officers of the various states for their consideration, comment and criticism.

These regulations, when finally adopted, will mark a distinct step forward in the safeguarding of the manufacture and handling of dangerous chemicals.

Of far more importance to industrial workers than the control of the manufacture of tetraethyl lead is the suggestion for regulations covering the sanitation of garages. During the recent investigations of the United States Public Health Service of the possible health hazard from the use of tetraethyl lead gasoline, it was found that lead was present in the dust of ordinary garages, and in one instance it formed as much as 1 per cent of the total inorganic matter. The extent of this health hazard is at once apparent, and the necessity for sanitary regulation is obvious.

Machinery Exports to Czechoslovakia Increase

Czechoslovakia imported metal-working machinery valued at approximately $1,934,000 in 1925, as compared with $1,101,000 in 1924. The countries supplying the largest portion of this trade were Germany and the United States, furnishing 71 per cent and 15 per cent respectively. While the German share represented a slight decline from that of the previous year, the American percentage more than doubled.

In addition to this increased share of the United States in Czechoslovakia's imports of metal-working machinery, the value of the American shipment nearly trebled as compared with those of 1924. This is especially noteworthy when it is considered that the price per ton of the American equipment was double that of the German—$1,059 and $534, respectively.

While Germany has, of course, the advantage of geographical location, together with a close acquaintance with the people and trade customs of Czechoslovakia, it is evident from the above that buyers recognize the superiority of at least certain types of American machinery. The encouraging advance that has already been made in this market indicates the possibility of further extending this trade through a closer study of the market, more intelligent and persistent sales effort, and the establishment of better distribution facilities.

Czechoslovakia is not only an import market for metal-working machinery, but is even more important as an exporter of this class of equipment. In fact, Czechoslovakia has been able to market these products in such advanced machinery producing countries as Germany and Great Britain. The former country occupied the interesting position in 1925, of being not only the most important source, but also the largest purchaser, of Czechoslovakia's metal-working machinery.

Metal-working machinery represented the only important class of industrial equipment, with the exception of textile and sewing machinery, in which the Czech imports exceeded the exports. Imports of machinery in general amounted to only 63 per cent of the exports.

Test Draft Gears on Railway Equipment

With a view to further increasing public safety and comfort while traveling and reducing loss and damage both to freight shipments and to railway equipment, a thorough study of draft gears used on both freight and passenger cars is to be made by the American Railway Association to determine what improvements can be made in the types already in use on the railroads of this country.

The American Railway Association has authorized an appropriation for the purpose of building, installing and housing a specially constructed machine for testing draft gears in order to ascertain their capacity, absorption of recoil and endurance. From the information obtained, the association plans to prepare suitable specifications under which the railroads may purchase draft gears that are known to meet the prescribed standards of efficiency.

The machine for testing draft gears, which is now being constructed, will be the largest that has ever been used for the purpose. A novel feature of the machine will be two falling weights, the larger one weighing 27,000 lb. and the smaller one 9,000 lb., the latter being the weight most frequently used heretofore in similar test machines. The machine will be driven electrically, the control equipment being so designed that operation may be manually or automatically controlled. It will be equipped with various devices to record the action of draft gears under various tests.

The machine when completed will be installed by the American Railway Association at one of the leading engineering universities, probably Purdue University at Lafayette, Ind., where the association has already installed special equipment and is conducting an elaborate series of tests of air brakes.

Foundry Instructors Will Confer

Following the very successful meeting of foundry instructors held in conjunction with the 1925 Syracuse meeting of the American Foundrymen's Association, plans have been made to make this meeting an annual affair. The second meeting will be held in Detroit at the time of the second international foundrymen's congress in late September. Foundry instructors in the various technical colleges and schools throughout the country have been invited to participate. The business of the meeting will take the form of reading of short papers descriptive of the foundry courses at Purdue University, Carnegie Institute of Technology, and the Universities of Michigan and Illinois. Following the reading of the papers, the meeting will be thrown open for a general discussion of foundry instruction.

All foundry instructors attending the meeting will be invited to participate in the technical sessions of the Foundrymen's Congress and to inspect the exhibit of foundry equipment and supplies.

No Need for Many of Our Small Industries

An interesting comment on the present day tendency to consolidate business enterprises is found in a statement issued recently by John F. Sherman, prominent engineer and president of the Sherman Corporation.

"Factories and mills in every line are heavily over-capacitated according to surveys which we have just made," says Mr. Sherman. "Instead of working 300 days a year thousands of employees are working 200 or 150. Companies are carrying the burden of unused floor space, of machinery not fully employed.

"At the same time, new companies are being formed to turn out products and sell them. Many of these products could be manufactured in plants now suffering from over-capacitation thus increasing employment, cutting costs and eliminating waste of capital

"There is little if any economic justification for many new companies. They waste millions in capital, frequently benefitting only that small portion of society which profits by financial promotion. They originate in the desire of some individual to make a fortune out of a new alarm clock, a reversible rubber heel, an automatic window opener, or some other products which we could very well get along without. Many of these ideas and projects can be used to absorb our present industrial over-capacitation."

Fifty Thousand Students in Engineering Schools

Enrollment in engineering colleges and schools throughout the United States for the school year of 1925-1926 numbers 56,332, according to a special report by the Bureau of Education.

The report covers 143 educational institutions where various branches of engineering are taught. It shows electrical engineering heading the list with 18,204 students. Civil engineering is next with 12,502 while third on the list is mechanical engineering the number of students taking this course amounting to 10,662. Other courses are chemical engineering with 4,887 students, architectural engineering with 2,529 students and mining and metallurgy with 2,076 students.

Motor Sales and Output Increased in March

March records in sales and output were reported to the directors meeting of the National Automobile Chamber of Commerce held in New York on April first. The production total based on individual factory shipping statements is estimated at 447,185.

While the figure reaches a new high, it is not out of line with the trend of growth, being close to the normal line. March is always one of the high production months. This year it is 18 per cent ahead of the average for March in the past three years, but this is not taken by the industry to indicate that 1926 will go very far ahead of 1925. It is felt that last year was an excellent business year and that a normal increase will be as much as can be expected.

Several companies reported in various sections that sales had broken all records during the past few weeks. February was virtually a closed month for the Northern part of the country due to the bad weather, with the result that stocks increased during this period and orders were delayed until March.

The Government tax reduction on automobiles which has been credited to the consumer by the manufacturers is now in effect and is expected to have a healthy influence on sales.

While March was a new high for the third month, it was the second high for all time, as October, 1925, registered an output of 452,486.

Trade Exhibit Fosters Export Business

A new method of fostering a greater volume of export trade, especially to Central and South American countries, is being tried in the International Trade Exhibition in New Orleans, which opened on Feb. 1. The exhibition is planned to be a permanent trade market wherein raw and fabricated products are exhibited and where buyers and sellers may meet to promote the trade and commerce of their respective countries.

The United States Government has co-operated by turning over the army base building, rent free. The trade exhibition is a non-profit, co-operative institution and is indorsed by banking, industrial, commercial and trade organizations, as well as by the United States Government, the State of Louisiana and the city government of New Orleans.

The income from the rental of space, after payment of expenses, will be used for publicity and other services for the sole benefit of exhibitors. The exhibitors will be entitled free to the services of interpreters, credit information, solution of transportation problems and information relating to tariffs, packing of goods and locating new markets. A feature of the plan is the payment of transportation of accredited buyers from any point in Central and South America, Cuba and Porto Rico to New Orleans and return. Electric power is furnished free.

It is planned to make the exhibition a permanent trade exhibition, open 365 days in the year. There are now about 200 exhibitors.

Boys Learn Sheet Metal Work

A class in sheet metal pattern drafting has been operated this winter by Peter Gray & Sons, Inc., sheet metal workers at East Cambridge, Mass. Instruction is given two evenings each week at the rooms of the Manufacturers' Association. Supper is served, after which the tables are cleared and the lesson begins, ending about eight o'clock, giving the boys an opportunity to use the evening for other entertainment. No expense is attached, as all drawing materials and suppers are paid for by the firm. The class is instructed by Peter Robertson.

Foreign Trade Policies and Practices on Council Program

Topics of foreign trade policy and practice affecting every section of the United States will be discussed at the 1926 National Foreign Trade Convention by speakers of nation-wide prominence in business affairs. The meeting place is Charleston, S. C., April 28, 29 and 30.

James A. Farrell, chairman of the National Foreign Trade Council, will open the convention with an address on "The Foreign Trade Outlook." The gathering will bring together 1,500 foreign trade executives from more than 30 states and is the first large convention of the kind ever held on the South Atlantic coast.

An outstanding event of the occasion will be an address by Henry M. Robinson, president of the First National Bank of Los Angeles, on "The European Situation of 1926."

The foreign traders will also hear from C. C. Martin, credit manager, the National Paper and Type Co., New York, what foreign business men have been saying for the past few years about the concrete effects of American competition abroad. Mr. Martin's address on "Making American Competition Effective" is the closing speech of the convention. Other important addresses on themes of widespread public interest will include "The Import Element of our Foreign Trade," a frank discussion of our sources of supply for American manufacturers, by Fred I. Kent, vice-president, the Bankers Trust Co., New York; "Building Trade Through Foreign Loans," by Paul J. Kruesi, president, the Southern Ferro Alloys Co., Chattanooga; "The Problem of the Far East," by Dr. Jeremiah W. Jenks, former adviser to the government of China; and "Communications—The Electric Nerves of Trade," by John L. Merrill, president, the All American Cables Co.

Southern manufacturers and export interests will be strongly represented at the convention and have co-operated in adding a strong Southern theme to the convention. Among the topics for this phase of the program are: "Commercial Possibilities of the South Atlantic," by R. Goodwyn Rhett, president of the Peoples-First National Bank of Charleston and former president of the United States Chamber of Commerce; "The South's Part in American Exports," by George G. Crawford, president, the Tennessee Coal, Iron and Railroad Co; "Economic Resources of the South Atlantic," by Dr. Erich W. Zimmerman, University of North Carolina; "Inland Rate Structure of the Southeast," by Thomas J. Burke, traffic commissioner; and an address on the problems of cotton in American foreign trade by a leading cotton authority to be selected later.

Group sessions will be held with the American Manufacturers' Export Association, the Export Managers' Club of New York, the National Association of Credit Men, and the foreign trade sections of national advertising and bankers associations.

The Business Barometer

This week's outlook in Commerce, Finance, Agriculture and Industry based on current developments

By Theodore H. Price
Editor, *Commerce and Finance, New York*

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AMONG the questions that are now agitating business one is so pervasive and of such dominant importance that everyone is repeating it and nearly everyone is answering it, either categorically or by presenting facts and opinions to be weighed. It is this: Does the drastic break in stocks portend a recession in business, possibly of equal severity?

The question arises naturally in a nation which has been educated to believe that the stock market is a business barometer of the first importance. Undoubtedly the belief was justified once, and that not long ago. But we are confident that it is now less valid than at any previous time in our history, and that before many more years are gone we shall label it a superstition and eventually erase it from our serious consideration. The reason is that such an accumulation of capital—and gold—has been amassed in the United States and concentrated through the Federal Reserve System, that not even the most extreme advance in stocks and in real-estate can suck dry the reservoirs of credit. And as long as industry can obtain the funds it needs at a reasonable charge, it will continue to provide work for everyone who desires it,—which is to say that a recession to the point of genuine depression is only a remote possibility.

Examination of the business news of last week shows no evidence that the decline in stocks has frightened buyers much or affected the state of trade in any tangible way. In the country's basic industry, March pig-iron output was the largest in a year, steel ingot production probably broke all records, the U. S. Steel Corporation is operating at 100 per cent of capacity, and orders placed during the last week of the month showed the same gain over February that was reported for the preceding three weeks.

In the automobile industry March output far exceeded previous figures for the month. Most manufacturers say the same thing of their sales, and while they have now accumulated stocks and are beginning to retard production slightly, their optimism regarding the future remains unabated.

To the retail trade the stock market is of immeasurably less concern than the weather. The figures for February compiled by the Federal Reserve Board show substantial increases in per diem rate over both January and a year ago.

Far from showing the decline that has been anticipated, building contracts awarded are larger than a year ago, by a good margin, and the authorities say that for the first half year a physical volume substantially above the same period in 1925 is now assured.

Railway car loadings are running satisfactorily ahead of last year. The record of checks cashed as compiled by the Reserve Banks, even if New York is eliminated, shows that the country's business is exceeding last year by 5 to 10 per cent weekly. Financing of this business, even though complicated temporarily last week by end-month transfers, has gone on without making an appreciable drain on our credit supply, as a reserve ratio of 73.4 per cent for the twelve Reserve Banks shows.

Most of the major commodities are steady. Wheat is hard to put down; the statistical position points to present firmness, although a large crop this year is now expected. In cotton the reverse is the case; the statistics are bearish but bad weather has shaken some of the confidence in another bumper crop to come and the market has advanced a little. Corn is dragging. Sugar is distinctly better because the Cuban mills are beginning to shut down and the season of increased consumption is at hand. Silk, rubber, hides and leather are steadier at the declines recently established, although none of them seem likely to advance again immediately and the perch of rubber on a price level four times the cost of production is rather precarious. Copper has recovered to 14 cents after several days of shading that quotation.

As for stocks, the recovery that began in the middle of last week was generally considered overdue and the early week decline might have been less drastic but for a second shock that the rails had to endure in the instruction of the Interstate Commerce Commission to the Chesapeake & Ohio to finance certain of its capital requirements by the issuance of new stock rather than the sale of bonds. This was the pretext for a final bear drive; at its culmination one or two of the market's "sore spots" were removed, and apparently the worst of the immediate liquidation is now past. The extension of loans to the Van Sweringens for another year is construed as signifying that they will again try to complete the Nickel Plate Merger, and rail consolidations may yet exert additional inflammatory effect upon the market.

If this summing up of the present state of business is correct it is evident that a satisfactory first half year is virtually assured. Beyond that it behooves the lookout to look backward as well as forward, and to see what the reasonable expectations for the second half year were before assuming that they will be disappointed. The reaction from the stock market boom and the passing of the Florida real estate speculation during the first quarter of the year were generally foreseen, and a recession in building activity and in steel and automobile production about the same time were expected by many keen observers. Since the first half of the prediction has now come true the fulfillment of the second part is within the early possibilities. Having been so clearly heralded it is already being discounted in continued cautious buying, and as long as business keeps its affairs so well in order and its inventories low, nothing more than the normal slowing down is anticipated.

What's Doing in Industry

Little change is observed in the machine tool and machinery markets at the present time. Orders are for the most part for special high production machines and few standard tools are being bought in large lots. Small tools and shop supplies are moving in good volume, and inquiries to date forecast a steady business for the second quarter of the year.

New England reports unusual activity among automobile accessory and electrical goods manufacturers. In Buffalo dealers are doing a fair business with contractors and automotive shops. Special machines in small lots or single pieces furnish the bulk of present business in New York.

The Middle-West continues at a steady pace. Detroit sales are better distributed, automobile plants buying conservatively. Chicago reports a normal development, while Cincinnati reports a slight increase in sales with more promising inquiries for future deliveries.

Cleveland dealers and manufacturers are optimistic over a better tone in their market. Automotive and farm implement manufacturers in the Indianapolis territory are buying more than heretofore.

Activity in railroad repair shops and large industrial projects are furnishing good business in Canada.

February export figures show a slight decline in shipments of machinery. The value decreased about $300,000 from January. Thread cutting machines, drills and grinders were in greatest demand.

The Industrial Review

Progress of the machinery and machine-tool business in various parts of the country

THE following reports, gathered from the various machinery and machine tool centers of the country, indicate the trend of business in these industries and what may be expected from the future:

Buffalo

Reports from machine tool dealers of Buffalo indicate that March is as good as February or January as a business month in this line, and some report it even better. Sales still continue to be made chiefly of single pieces of equipment but the number of buyers makes a considerable bulk.

The outlook for the future is not one of unmixed optimism. Some dealers are highly optimistic and predict that the second quarter of the year will be better than the first, but there are a few who are rather uneasy.

The demand for contractors' equipment still continues to be good. The Buffalo automotive industry is in a healthy condition and much more active than last year at this time. There is no railroad activity locally.

Cleveland

Sales of machinery and machine tools showed a decided spurt in the last week of March and exceeded all other high peaks within the last two months. Automotive and railroads were the chief purchasers and with the advent of a large influx of inquiries from the general industries it is the opinion of the local trade that the "spring buying" period is underway.

The total volume of sales for the first quarter of the year shows a substantial increase over the same quarter of 1925. Several instances were reported where sales were doubled. An analysis of the first three months showed a steady unward trend.

Road building and contractors' equipment dealers are experiencing a season of activity due to the large request for machinery of this type.

Cincinnati

With one or two exceptions Cincinnati machine tool manufacturers report increased sales in the past week, and in no case is a decrease of business reported. Selling agents report that they had some increase in orders, and an increased number of inquiries leads them to regard the outlook as encouraging.

Sales of single tools for replacement purposes was the market feature of the week. Plants are fairly busy, employing normal forces, but the production is being confined rather closely to the immediate market requirements.

The week's buying was well scattered, with orders coming from a variety of users. The automotive industries did some buying. Railroad buying was confined to single purchases.

An increased number of inquiries are coming in, and this fact is regarded as indicative of a better market in the near future.

Milwaukee

Metal-working equipment is moving in a moderate way, and the situation is described as satisfactory, both by manufacturers and dealers. While the size of the individual order has undergone some apparent shrinkage, the volume is fairly well maintained by reason of the larger number of buyers. The quietude which developed about the middle of March was mainly superficial, judging by the actual sales the whole month produced.

In some quarters there has been a slackening of inquiry. The automobile trade is hardly as active a buying group as it was a year ago. The principal needs appear to have been filled for the present. The demand now is mainly for replacement, or for the latest types to reduce man-power needs and increase output.

Railroad business is disappointing. Only the most urgent replacements are being made locally.

The metal trades in Milwaukee and vicinity are lending the tool trade good support, and one of the encouraging features of the situation is that shops are busy, with good orders ahead that presage a continuance of the present satisfactory rate of activity for several months to come.

Indianapolis

Little change is to be seen in machine tool trade here during the last two weeks. In fact, the trade is doing well to uphold the standard set during the first two weeks of March. Manufacturers and agents say the situation is far from discouraging and they are predicting a good spring business.

The automotive trade continues a good buyer. Business with Indiana automobile manufacturers is good and production is being maintained at a fairly high level. Some additions and replacements are being made.

Railroads are making some purchases in this state, but the volume is rather small and repair work this spring likely will be held to a minimum. Sales of contractors' equipment have fallen off during the last two weeks.

Sales of special machinery to brick manufacturing plants have shown an increase. Sales to furniture and lumber factories have fallen down. Business from the coal mines is slow.

New York

The demand for special high production machinery affords a particularly pleasing feature of the present situation in the machinery business in this market. Orders for standard machines are not plentiful, few replacements being made at this time. But orders for machines of new design for special work are coming in at a satisfactory rate and inquiries on hand forecast a good future business.

The first quarter proved profitable for most dealers and agents in this territory, and the belief is general that the next three months will see the volume maintained.

Much is expected from the railroads. A better financial position and the fact that little buying of shop equipment was done last year, combine to strengthen this expectation.

Present orders are scattered and call for a large variety of tools. Boring mills, rotary planers, profiling and nibbling machines and hand millers were prominent in the weeks committments.

Chicago

The last week of March found the machine tool market practically in the same condition that has characterized it since the month began. While dealers uniformly speak of business as inactive, there are exceptions to this rule. Inquiries received are normal for this time of year, but the closing of sales, except for small lots, is slow.

There is one feature of the machinery trade upon which practically all the larger dealers agree, that is the diversity of industries from which such business as is being done is derived, and the increased Mid-West territory contributing to the machine-tool trade of Chicago. This, dealers declare, is decidedly better on the whole than having to depend on four or five of the country's leading industries, as was formerly the case.

Railroads are still holding off on the matter of closing, the Florida East Coast R.R. being the only one to have started in this direction.

A satisfactory phase of the present market situation is reported from manufacturers of wood-working machinery, demand for which has been steadily growing with each succeeding month since the first of this year.

Canada

Activity in railroad shops, car building plants and automotive factories is stimulating demand for machine tools and machinery in Canada. The Canadian Pacific Ry. has announced that $14,794,640 will be spent this year for equipment, including freight cars and work units and locomotives.

Production is being speeded up to a high degree in the iron and steel industry as consumers book new business and find themselves in need of supplies. The rail mill of the Algoma Steel Corporation will resume operations. Buying in the metal markets of Montreal is reported to be much more active than for some weeks.

Implement men in western Canada are looking forward to a record business this year. Some can show more spring business contracted for this year than for the whole of 1924. If present plans materialize, the Canadian branch of the Durant Motor Co. will enter the export market, which would practically double the output of the Toronto plant.

New England

The first quarter of 1926 has been turned and builders of machinery in the New England territory are found in a pleased frame of mind. The output for the first three months has surpassed any corresponding period in the last five years, and orders on hand are ahead of any quarter in the same period. The volume of prospective business is cause for satisfaction.

Builders of heavy production machinery are especially gratified with conditions. Although manufacturers of small tools do not fully share in the satisfaction as to business in the first quarter, the sentiment is that their prospects are particularly good. A considerable part of the business has been the replacement variety, with scattered orders for expansion. A study of the sales shows an improvement in foreign trade.

The automotive industry predominated in the buying, although there were conspicuous representations of the electrical and radio trades. Buying by railroads has been good. Employment has been on full-time schedules throughout the territory and working forces in many instances have been increased.

Detroit

A survey of machinery and machine tool representatives in Detroit shows that sales have steadied considerably during the past few days, and a more or less uniform volume of business is in sight for the next few weeks. The demands of the automobile plants for special machinery have been satisfactorily met.

Milling machines and multiple-spindle drills are in demand just now. Manufacturing activities are more quiet than they were, and there is a tendency to let industrial conditions right themselves.

The smaller shops in Detroit are finding the going rather hard at present. Firms formerly taking advantage of discounts for cash are taking longer to pay for equipment, while some of the manufacturers are refusing to extend credit in buying any extensive machinery.

The Packard Motor Car Co. has bought some special machines. A few brake gear hoppers have been purchased by the Ford Motor Co., and several automatic milling machines are being placed in the Buick plant at Flint. The recent organization of the American Car and Foundry Motors Co. in Detroit is destined eventually to mean some large orders of machinery. Chrysler and Dodge have each purchased some toolroom equipment.

Personals

R. F. INGRAM has been appointed sales manager for the Landis Tool Co., of Waynesboro, Pa. He succeeds Mr. Nevin.

GLEN OVERTON has been elected president of the American Machine Co., of Benton Harbor, Michigan.

W. B. MCBURNEY, 616 Trust Bldg., Atlanta, Ga., has been appointed representative in Georgia and eastern Tennessee for the Uehling Instrument Co., of Paterson, N. J.

MAURICE R. HART, for the past several years associated in the production and sales departments of the Morse Chain Co., has been appointed manager of the Buffalo, N. Y., office of that company.

E. W. KRAUSE has been re-elected president of the Wheeling Machine Products Co., of Wheeling, W. Va. Alfred Briese has been elected vice-president and production manager, and A. C. Kennen secretary.

HOWARD BECKETT, formerly general manager of the National Recording Pump Co., of Dayton, Ohio, has been appointed chief draftsman for the Dayton Pump Manufacturing Co., also of Dayton.

T. R. SANDERS, of 180 Milk St., Boston, Mass., has been appointed district representative for the Foote Bros. Gear and Machine Co., of Chicago. He will cover Rhode Island and the Eastern half of Massachusetts.

W. LEDYARD MITCHELL has been promoted to vice-president and general manager of operations of the Chrysler Corporation, and has assumed direction of the three main Detroit plants as well as those in New Castle, Indiana, and Dayton, Ohio.

ROBERT E. LAIDLAW, superintendent of the Northern division of the Michigan Central Railroad at Bay City, Michigan, for the last five years, has been appointed superintendent of the Detroit division with headquarters in Detroit.

RUSSELL HUFF former president of the Society of Automotive Engineers, has resigned as director of engineering of Dodge Brothers, Inc. Mr. Huff was consulting engineer of the Packard Motor Car Co. for more than 15 years before going to the Dodge organization.

EDWARD T. KLEE, one of the oldest members of the Stutz Motor Car Co.'s mechanical staff, has been appointed assistant production manager of the Indianapolis plant. H. C. Kramer has been appointed master mechanic of the factory. Mr. Kramer comes to Indianapolis from Rochester, N. Y.

K. T. KELLER has been appointed vice-president in charge of manufacturing of the Chrysler Corporation, and assumed his new duties on April 1. Mr. Keller was at different times associated with the General Motors Corporation, Northway Motors, and the Buick Motor Car Co.

ROSS H. MCMASTER has been elected president of the Steel Co. of Canada, Ltd. Harry H. Champ has been elected vice-president. Homer M. Jacques, manager of the eastern plants, has been elected to the board of directors, filling the vacancy created by the death of Robert Hobson.

THOMAS J. LITTLE, JR., formerly chief engineer of the Lincoln division of the Ford Motor Co., has become associated with the Copeland Products, Inc., manufacturer of electrical refrigerating systems. He is vice-president in charge of engineering and development.

GORDON LEFEBVRE has been appointed general manager of the General Motors of Canada, Ltd., Oshawa, Ontario, to succeed K. T. Keller, who has severed his connection with the company after having occupied the position of vice-president and general manager for the last three years. Mr. Lefebvre was formerly Chevrolet production manager, with headquarters in Detroit.

JAMES F. MILLER, president and general manager of the Miller-Hurst Corporation, of Detroit, specialist in production methods and equipment for foundries and factories, and also president and general manager of the Interstate Foundries, Inc., of Cleveland, has resigned from the latter position. After a month's rest Mr. Miller will devote his entire time to the Miller-Hurst Corporation, of which he was one of the founders.

H. S. VANCE, of South Bend, has been appointed vice-president in charge of manufacturing for the Studebaker Corporation. He succeeds M. F. Wollering who resigned. Mr. Vance began with Studebaker in 1910 as a mechanic and successively occupied positions of inspector, storekeeper, general storekeeper, supervisor of specifications and stores, assistant treasurer, purchasing agent, assistant to the vice-president in charge of manufacturing, assistant to the president, export sales manager and sales manager.

E. H. SNIFFIN has been appointed assistant to the vice-president of the Westinghouse Electric and Manufacturing Co. Other recent appointments include: T. J. Pace, director of Sales; G. H. Frobel, central station manager; J. M. Curtin, industrial sales manager; M. B. Lambert, transportation sales manager; A. C. Streamer, assistant director of sales; H. W. Smith, generating apparatus manager; A. J. Manson, traction apparatus manager; O. F. Stroman, motor apparatus manager; R. A. Neal, switch gear apparatus manager, and G. A. Sawin, distribution apparatus manager.

Business Items

The Servel Co. has been incorporated at Dover, Del., to manufacture and deal in refrigerating machines and appliances.

Battey & Kipp, Inc., engineers, announce the removal of their offices to Suite 2086, Illinois Merchants Bank Bldg., Chicago.

The Manufacturing Equipment and Engineering Co., of Boston, Mass., has just completed the erection of a new addition to its plant at Framingham, Mass.

The Black & Decker Manufacturing Co., of Towson, Md., announces the establishment of the Black & Decker Manufacturing Co., Ltd., in London, England. Cecil M. Peter is managing director.

The Holly Machine Tool Co. has been organized in Holly, Michigan, by T. L. Dilley and Earl Padgett. It will manufacture tools, dies, jigs and special machinery.

Day & Zimmermann, Inc., engineers, announce the opening of a foreign office in Paris, France. This office is in charge of Robert D. McCarter, vice-president of the company.

E. A. Bowman, Inc., of Detroit, has been appointed distributor of the automotive end of the American Bosch Magneto Corporation. The Black & Decker line of electric drills has also been added to the account of this company.

The Cisco Machine Tool Co., of Cincinnati, has purchased the Mueller Machine Tool Co., also of Cincinnati, and will continue the manufacture of Mueller radial drills of all types, but will only furnish repair parts for the lathes formerly made by the Mueller company.

The Chicago Pneumatic Tool Co. has acquired the George Oldham & Sons Co., of Baltimore. The manufacture of Oldham products will be conducted at the Detroit plant of the Chicago company and sales will be handled through the various branches of that organization.

The Sesamee Co., Hartford, Conn., has incorporated to manufacture keyless locks. The company has leased a part of the Standard Screw Co. and will produce its products there. The incorporators are A. G. Hatch, Philip B. Gale, president of the Standard Screw Co.; and Douglas H. Thomson, of Thomson-Fenn & Co.

Henry Disston & Sons, manufacturers of saws, files, tools and steel, will open a new branch in Detroit to be located as 620 East Hancock Ave., and consisting of a warehouse, office and necessary equipment for servicing. Steel sales will be in charge of K. L. Clark and mill goods under L. L. Mather, both of whom have been Disston representatives for some time..

Joseph T. Ryerson & Son Inc. have just completed arrangements with F. A. Brandes of the Brandes Machinery Co., Keith Bldg., Cleveland, to represent them exclusively on their complete line of metal-working machinery and small tools.

Mr. Brandes has co-operated with manufacturers in the Cleveland territory for many years and will now be subject to call in working out metal working problems and servicing the tools now in use.

D. W. Pedrick, Pioneer in Machinery Industry, Is Dead

Daniel W. Pedrick, founder of the Pedrick Tool and Machine Co., of Philadelphia, died in that city on Feb. 10. He was 86 years old.

Mr. Pedrick was one of the pioneers in the machinery building industry, his first venture being as the owner of an iron foundry in Philadelphia in 1871. Here he made the acquaintance of executives of the Baldwin Locomotive Works and was induced to take charge of the L. B. Flanders Machine Works. On the death of Mr. Flanders Mr. Pedrick was made a part owner of the business. Later he secured control of the company and took in a Mr. Ayer as a partner, the firm name being changed to Pedrick & Ayer.

The company prospered with the better times following the Civil War and expanded into the machine tool line, making a specialty of heavy machines for roalroad work. Among the inventions of Mr. Pedrick were boring bars, milling machines, open-side planers and special machines for railway repair work.

The firm name was changed some time ago to the Pedrick Tool and Machine Co., and while Mr. Pedrick acted in an advisory capacity the business was actually carried on by his two sons, Albert D. and Howard A. Pedrick, who will continue the business.

Obituaries

AURAS G. DAWSON, for several years associated in an executive capacity with the Apperson Automobile Co., died recently at his home in Kokomo, Ind.

HARBERT W. CHENEY, for many years associated with the Allis-Chalmers Manufacturing Co., as electrical engineer, died at his home in Milwaukee on March 23.

HORACE C. HIDES, general manager of Thomas Firth & Sons, Inc., of Hartford, Conn., died on March 19. Mr. Hides was associated with the steel industry for many years, his career starting in England with William Jessop & Sons, of Sheffield.

JAMES O. BARRETT, president and one of the founders of the Barrett Machine Tool Co., of Meadville, Pa., died at his home in that city on March 19. Mr. Barrett had specialized in the manufacture of boring machines of his own design.

ORA P. HAND, president of the Burd High Compression Ring Co., of Rockford, Ill., died on March 31. He was 51 years old. Mr. Hand became associated with the Burd organization eleven years ago as sales manager and soon after was elected to the presidency.

GEORGE T. CLARK, master mechanic at the Saco-Lowell Shops, died on March 24, at Biddleford, Me. Mr. Clark was born in Saco, Me., 51 years ago, and went to work for the Saco Lowell Co., at the age of 21. For the past 15 years he has held the position of master mechanic.

ALEXANDER BLASER, welding and cutting expert for the Air Reduction Sales Co., of New York, died at his home in Union City, N. J., on March 24. He was 41 years old. Mr. Blaser was born in Switzerland and came to the United States when he was 12 years old. He learned the coppersmith's trade and was first employed by the Davis-Bournonville Co. When that company began to develop oxyacetyalene welding and cutting processes, Mr. Blaser became an expert and excelled in the cutting of tool steel dies and similar work.

Slight Decrease in Exports in February

Exports of metal-working machinery for February, with revised comparative figures for February, 1925, as compiled by the Department of Commerce, are as follows:

	February 1925 Value	February 1926 Value
Lathes	$138,080	.....
Boring and drilling machine tools	36,212	.....
Planers, shapers and slotters	34,033	.....
Bending and power presses	12,368	.....
Gear cutting machines	98,980	.....
Milling machines	44,018	.....
Punching and shearing machines	5,793	.....
Power hammers	12,657	.....
Other metal working machinery and parts of	366,695	.....
Engine lathes	.....	$44,922
Turret lathes	.....	52,440
Other lathes	.....	78,747
Vertical boring mills and chucking machines	.....	5,700
Thread cutting and automatic screw machines	32,807	44,972
Knee and column type milling machines	.....	15,333
Other milling machines	.....	43,353
Disk type gear cutting machines	.....	.....
Other gear cutting machines	.....	49,368
Vertical drilling machines	.....	8,092
Radial drilling machines	.....	9,791
Sensitive drilling machines	.....	1,046
Other drilling machines	.....	8,093
Metal sawing and cutting-off machines	.....	1,877
Shapers and slotters	.....	11,476
Planers	.....	1,247
External cylindrical grinding machines	145,982	93,324
Internal grinding machines	5,870	43,478
Metal-working tool sharpening machines	.....	25,308
Other metal grinding machines	31,493	19,548
Sheet metal-working machines	.....	70,388
Plate metal-working machines	.....	343
Rod or wire-working machines	.....	2,475
Forging machinery	.....	80,913
Rolling mill machinery	.....	20,127
Foundry and molding equipment	42,096	27,083
Other power-driven, metal-working machinery and parts	.....	216,987
Other metal-working machinery (total)	281,499	318,503
Hand or foot operated metal-working machinery and parts	.....	12,903
Pneumatic portable tools	76,385	111,456
Other portable metal-working machines	.....	34,656
Chucks for machine tools	18,950	25,817
Reamers, cutters, drills, taps, dies and other metal working tools	186,164	133,671
	$1,894,082	$1,613,437

Trade Catalogs

Micarta Gears. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. Booklet C-1579-D on Micarta gears and pinions contains twenty 8½x11-in. pages. A change in the computation of the horsepower ratings of Micarta gears, based on the use of a fiber stress figure of 6,000 lb. instead of the 5,000 lb., previously used, is fully described.

The booklet contains tables valuable especially to the gear manufacturer, relating to calculations on the gears. Examples are given and tables list the preferred pitch, the values of the constants used, gear data and horsepower ratings at various pitches.

In the beginning of the book is given a short description of the characteristics and advantages of Micarta in reference to gears.

Small Tools. The Brown & Sharpe Manufacturing Co., Providence, R. I., has issued its Catalog No. 30, containing 448 pages, 4½x6½ in. The catalog lists over 2,000 tools manufactured by the company.

Illustrations are given showing tools in actual use and reference tables and suggestions are included. Many tables of formulas and useful information on various subjects are given.

The catalog is very fully illustrated and the views showing the instruments and tools in use form a valuable addition.

Calendar of Local Meetings

National Association of Cost Accountants

Philadelphia. April 9. Business Mathematics, Sinking Funds and Depreciation. E. P. Moxey, Jr., speaker.

New York. April 13. Interpreting Statistics.

Albany. April 14. Preparation and Administration of the Budget.

Chicago. April 15. How to Introduce Scientific Planning in Industry.

Milwaukee. April 16. Brass Foundry Costs.

Mohawk Valley. April 19. Plant inspection visit to Rome, N. Y.

Twin Cities. April 20. A Cost System for a Small Manufacturer.

Hartford. April 20. Dinner meeting. Address by Durward Earle Burchell of Harvard University.

Los Angeles. April 20. Costs as a Factor in Management, E. R. Maule.

Pittsburgh. April 21. The Costs of Cost System Installation and Operation.

Rochester. April 21. The Application of Incentive Wage Plans.

Syracuse. April 21. Practical Psychology in Business.

Cleveland. April 21. Use of Mechanical Appliances.

Boston. April 22. Standard Costs and Variations, A. R. Davis.

Buffalo. April 22. Profit and Loss Statements.

Detroit. April 22. Material Costs Control.

American Society for Steel Treating

Hartford. June. Spring sectional meeting.

Society of Automotive Engineers

Southern California. April 9. "Diesel Engines for Automotive Purposes," by T. B. Danckwortt.

Pennsylvania. April 13. "Motor Front End Drive," by Frank M. Hawley, Rcbt. S. Drummond, and a representative of the Diamond State Fibre Co.

Metropolitan. April 15. "Engines," by H. M. Crane.

Cleveland. April 19. Subject not announced.

Chicago. April 23. "Motorized Rail Car Development," by A. W. Scarratt.

American Society of Mechanical Engineers

New Haven. April 13. At the Mason Laboratory. Subject: "Transportation."

Baltimore. April 14. At the Engineers' Club. Papers to be presented by junior members.

Chicago. April 19. Joint meeting with Western Society of Engineers. Speaker: W. B. White, consulting engineer for the piano industry.

Buffalo, April 20. Hotel Statler. "Modern Diesel Engine Practice," by J. T. Clancy.

Houston. April 20. Annual dinner, University Club. Indianapolis. April 20. Joint meeting with the A.I.E.E. "Development of Steam Generators and Radiant Heat," by George A. Orrock.

Nebraska. April 21. Grand Hotel, Lincoln, Neb. "National Defense and Industrial Mobilization," by Dean P. F. Walker, the University of Kansas.

Toledo. April 22. Oil and Gas Power Week.

Atlanta. April 22. Joint meeting of the A.S.C.E., A.I.E.E., A.C.S. and A.S.M.E.

Cincinnati. April 23. "Training Apprentices," by P. C. Molter, National Metal Trades Association.

Colorado. April 23. Metropole Hotel, Denver. Dinner meeting.

Philadelphia. April 23. Engineers Club. "Oil and Gas Power."

New England Meeting. May 3 to 6. Providence, R. I. Chairman of program committee, Luther D. Burlingame.

Forthcoming Meetings

National Metal Trades Association. Twenty-eighth annual convention, Hotel Astor, New York, April 15 and 16. Secretary, J. E. Nyhan, Peoples Gas Bldg., Chicago, Ill.

American Welding Society. Annual meeting, Engineering Societies Bldg., New York City, April 21, 22 and 23.

National Foreign Trade Council. Thirteenth national foreign trade convention, Charleston, S. C., April 28, 29 and 30. O. K. Davis, secretary, India House, Hanover Square, New York.

American Gear Manufacturers' Association. Tenth annual meeting, Book-Cadillac Hotel, Detroit, May 13, 14 and 15. T. W. Owen, secretary, 2443 Prospect Ave., Cleveland, Ohio.

American Supply and Machinery Manufacturers' Association. Annual convention, Hotel Statler, St. Louis, week of May 17. F. D. Mitchell, secretary, 1819 Broadway, New York.

Society of Automotive Engineers. Summer meeting, French Lick Springs, Indiana, June 1 to 4. John Warner, manager of meetings, S. A. E., 29 West 29th St., New York City.

National Association of Purchasing Agents. Eleventh annual convention and exposition, Ambassador Hotel and Auditorium, Los Angeles, Calif., June 9 to 12. W. L. Chandler, secretary, Woolworth Bldg., New York.

American Railway Association. Annual meeting of the Mechanical Division (Master Car Builders and Master Mechanics), Atlantic City, N. J., June 9 to 16. V. R. Hawthorne, secretary, 431 So. Dearborn St., Chicago.

Railway Supply Manufacturers' Association. Annual convention and exhibit in conjunction with Division V, Mechanical, of the American Railway Association, Young's Million Dollar Pier, Atlantic City, June 9 to 16. J. D. Conway, secretary, 1841 Oliver Bldg., Pittsburgh.

Society of Industrial Engineers. Thirteenth national convention, Bellevue-Stratford Hotel, Philadelphia, June 16, 17 and 18. Executive secretary, George C. Dent, 608 S. Dearborn St., Chicago.

American Society for Testing Materials. Haddon Hall Hotel, Atlantic City, N. J., June 21 to 25. C. L. Warwick, secretary, 1315 Spruce St., Philadelphia.

American Society of Mechanical Engineers. Spring meeting, Palace Hotel, San Francisco, Calif., June 28 to July 1. Chairman of convention, Warren H. McBride, the California and Hawaiian Sugar Refining Co., 215 Market St., San Francisco.

American Railway Tool Foremen's Association. Annual convention, Hotel Sherman, Chicago, Sept. 1, 2 and 3. G. G. Macina, secretary, 11402 Calumet Ave., Chicago.

American Railway Tool Foremen's Supply Association. Annual exhibit in connection with the annual convention of the American Railway Tool Foremen's Association, Chicago, Sept. 1, 2 and 3.

American Society for Steel Treating. Eighth national steel and machine tool exposition, Municipal Pier, Chicago, Sept. 20 to 24. W. H. Eisenman, secretary, 4600 Prospect Ave., Cleveland, Ohio.

American Foundrymen's Association. Second international foundrymen's congress, Detroit, Sept. 27 to Oct. 1, under the auspices of the American Foundrymen's Association. R. E. Kennedy, secretary, 909 W. California St., Urbana, Ill.

The Weekly Price Guide

Rise and Fall of the Market

Iron and Steel—Pig iron demand is noticeably slower than a week ago; prices, however, remain firm and unchanged. Steel buying shows increasing activity with production at unusually high levels. Steel prices are slightly firmer, with plates up 10c. per 100 lb. from the Mar. 26 level at mills. Increasing consumption of steel for pipe and agricultural implements is contrasted with the present lessening in railroad requirements. Current prices f.o.b. Pittsburgh mills are: bars, $2@$2.10; shapes, $1.90@$2; and plates, $1.90 per 100 lb.

Non-Ferrous Materials—Copper, tin and lead hold firm at Mar. 26 levels in New York warehouses; zinc is up ¼c. per lb. Solder dropped ¼c. and babbitt metal (highest grade) ⅜c. per lb. during week. Fabricated brass and copper prices are lower at Cleveland and Chicago. Scrap non-ferrous metals tend downward with the exception of lead and zinc.

(All prices as of April 2)

IRON AND STEEL

PIG IRON—Per gross ton, f.o.b.:

CINCINNATI	
No. 2 Southern	$24.05
Northern Basic	24.27
Southern Ohio No. 2	24.27
NEW YORK—Tidewater Delivery	
Southern No. 2 (silicon 2.25@2.75)	28.37
BIRMINGHAM	
No. 2 Foundry	22.00
PHILADELPHIA	
Eastern Pa., No. 2x (silicon 2.25@2.75)	24.16
Virginia No. 2	29.17
Basic	23.16
CHICAGO	
No. 2 Foundry local	23.00
No. 2 Foundry, Southern (silicon 2.25@2.75)	26.55
PITTSBURGH, including freight charge ($1.76) from Valley	
No. 2 Foundry	22.27
Basic	22.27
Bessemer	22.27

IRON MACHINERY CASTINGS—Cost in cents per lb. of 100 flywheels, 6-in. face x 24-in. dia., hub not cored, good quality gray iron, weight 275 lb.:

Detroit	5.00@5.25
Cleveland	5.00@5.25
Cincinnati	5.00@5.50
New York	5.25@5.50
Chicago	5.25@5.75

SHEETS—Quotations are in cents per pound in various cities from warehouse; also the mill base in large lots.

Blue Annealed	Pittsburgh Mill Base	New York	Cleveland	Chicago
No. 10	2.45@2.50	3.89	3.25	3.50
No. 12	2.50@2.55	3.94	3.30	3.55
No. 14	2.55@2.60	3.99	3.35	3.60
No. 16	2.65@2.70	4.09	3.45	3.70
Black				
Nos. 18 to 20	3.05@3.15	4.30	3.90	3.90
Nos. 22 to 24	3.10@3.20	4.35	3.95	3.95
Nos. 26 and 27	3.15@3.25	4.40	4.00	4.00
No. 28	3.25@3.35	4.50	4.10	4.10
Galvanized				
No. 10	3.50@3.60	4.65	4.25	4.25
Nos. 12 to 14	3.60@3.70	4.75	4.35	4.35
No. 16	3.75@3.85	4.90	4.50	4.50
Nos. 18 to 20	3.90@4.00	5.05	4.65	4.65
Nos. 22 to 24	4.05@4.15	5.20	4.85	4.80
Nos. 26 and 27	4.20@4.30	5.35	5.10	4.95
No. 28	4.50@4.60	5.65	5.25	5.25

WELDED STEEL PIPE—Warehouse discounts are as follows:

	New York Black	New York Galv.	Cleveland Black	Cleveland Galv.	Chicago Black	Chicago Galv.
1 to 3 in. steel butt welded	53%	39%	55½%	43½%	54%	41%
2½ to 6 in. steel lap welded	48%	35%	53½%	40½%	51%	38%

Malleable fittings: Classes B and C, banded, from New York stock sell at list plus 4% less 5%. Cast iron, standard sizes, 36-5% off.

Size, Inches	List Price per Foot	Diameter in Inches External	Diameter in Inches Internal	Thickness Inches
1	$0.17	1.315	1.049	.133
1¼	.23	1.66	1.38	.14
1½	.27½	1.9	1.61	.145
2	.37	2.375	2.067	.154
2½	.58½	2.875	2.469	.203
3	.76½	3.5	3.068	.216
3½	.92	4.0	3.548	.226
4	1.09	4.5	4.026	.237
4½	1.27	5.0	4.506	.247
5	1.48	5.563	5.047	.258
6	1.92	6.625	6.065	.28

SEAMLESS STEEL TUBING—Following net prices are for seamless mechanical tubing, cold drawn, round, .10 to .30 carbon, at warehouse in lots of less than 100 ft.:

Thickness B.W.G. and Decimal	Fractions	Outside Diameter in Inches ⅛	¼	⅜	½	1	1½	1¾
		Price per Foot						
.035″	20	$0.15	$0.16	$0.17	$0.18	$0.19	$0.21	$0.23
.049″	18	.17	.18	.19	.20	.21	.23	.25
.065″	16	.19	.20	.21	.22	.23	.25	.27
.083″	14	.20	.22	.23	.24	.25	.27	.29
.095″	13	.21	.23	.25	.26	.27	.29	.31
.109″	12	.22	.24	.26	.27	.28	.30	.32
.120″ or .125″	11	.23	.25	.27	.28	.29	.31	.33
.134″	10	.24	.26	.28	.29	.30	.32	.34

MISCELLANEOUS—Warehouse prices in cents per pound in 100-lb. lots:

	New York	Cleveland	Chicago
Spring steel (light) (base)*	7.00	6.00@7.50	4.65†
Spring steel (heavier)	4.00	....	4.00
Coppered Bessemer rods (base)	6.05	6.00	6.20
Hoop steel	4.49	3.85	4.15
Cold rolled strip steel	6.25	6.35	6.25
Floor plates	5.25	5.60	5.50
Cold drawn shafting or screw	4.00	3.90	3.60
Cold drawn flats, squares	4.50	4.40	4.10
Structural shapes (base)	3.34	3.20	3.10
Soft steel bars (base)	3.24	3.10	3.00
Soft steel bar shapes (base)	3.24	3.11	3.10
Soft steel bands (base)	3.99	3.20	3.65
Tank plates (base)	3.34	3.40	3.10
Bar iron (3.00 at mill)	3.24	3.21	3.00
Drill rod (from list)	60@65%	55%	50%

Electric welding wire, New York, 3/32, 8.25c.; ⅛, 7.85c.; 5/32 to ¼, 7.35c. per lb. *Flat, 5/16@½-in. thick. †F.o.b. cars.

METALS

Current Prices in Cents Per Pound

Copper, electrolytic (up to carlots), New York			15.25
Tin, 5-ton lots, New York			66.00
Lead (up to carlots) E. St. Louis	8.00	New York	9.25
Zinc (up to carlots) E. St. Louis	7.17½	New York	8.25

	New York	Cleveland	Chicago
Antimony (Chinese), ton spot	19.50	24.00	26.00
Copper sheets, base	22.75	22.50	22.50
Copper wire, base	19.50	16.50	16.00
Copper bars, base	22.37½	22.12½	21.87½@22.12½
Copper tubing, base	24.50	24.25	24.25
Brass sheets, base	19.12½	18.87½	18.87½
Brass tubing, base	23.75	23.50	23.50
Brass rods, base	16.87½	16.62½	16.62½
Brass wire, base	19.62½	19.37½	19.37½

Shop Materials and Supplies

METALS—Continued

	New York	Cleveland	Chicago
Aluminium ingots, 98 to 99%, 1 to 15 ton lots	27.00	27.00	27.02
Zinc sheets (casks)	12.00	12.60@12.95	12.27
Solder (½ and ½), (case lots)	40.12½	42.00	38½@42½
Babbitt metal, delivered, New York, cents per lb.:			
Genuine, highest grade			81.62½
Commercial genuine, intermediate grade			56.00
Anti-friction metal, general service			31.50
No. 4 babbitt (f.o.b.)			14.00
Nickel, f.o.b. refinery, cents per lb.:			
Ingots 31.00 Electrolytic 38.00 Shot 32.00			

SPECIAL NICKEL AND ALLOYS—Price in cents per lb., f.o.b. Huntington, W. Va.:

Hot rolled nickel sheet (base)	52.00
Cold rolled nickel sheet (base)	60.00
Hot rolled rods, Grade "A" (base)	50.00
Cold drawn rods, Grade "A" (base)	58.00
Manganese nickel hot rolled rods "E"—low manganese (base)	54.00
Manganese nickel hot rolled rods "D"—high manganese (base)	57.00

Base price of Monel metal in cents per lb., f.o.b. Huntington, W. Va.:

Shot	32.00	Hot rolled rods (base)	40.00
Blocks	32.00	Cold drawn rods (base)	48.00
Ingots	38.00	Hot rolled sheets (base)	42.00
Cold rolled sheets (base)			50.00

OLD METALS—Dealers' purchasing prices in cents per pound:

	New York	Cleveland	Chicago
Crucible heavy copper	12.00@12.25	11.25	11.25@11.75
Copper, heavy, and wire	11.50@11.75	11.50	10.75@11.25
Copper, light, and bottoms	9.50@10.00	10.00	9.75@10.25
Heavy lead	7.12½@7.62½	7.50	6.75@7.25
Tea lead	5.00@5.25	5.00	5.50@6.00
Brass, heavy, yellow	7.25@7.50	7.25	7.50@8.00
Brass, heavy, red	9.50@9.75	9.50	8.75@9.25
Brass, light	6.25@6.50	6.00	7.00@7.50
No. 1 yellow rod turnings	8.50@8.75	8.00	7.75@8.25
Zinc	4.50@5.00	4.75	4.25@4.75

TIN PLATES—American Charcoal—Bright—Per box.

		New York	Cleveland	Chicago
"AAA" Grade:				
IC,	14x20	$11.25	$11.45	$11.50
"A" Grade:				
IC,	14x20	8.85	9.40	9.50
Coke Plates—Primes—Per box				
100-lb.,	14x20	6.45	6.10	7.00
Terne Plates—Small lots, 8-lb. Coating—Per box				
IC,	14x20	7.85	6.95	7.50

MISCELLANEOUS

	New York	Cleveland	Chicago
Cotton waste, white, per lb.	$0.13@0.17½	$0.19	$0.20
Cotton waste, colored, per lb.	.10@.14	.10	.17
Wiping cloths, washed white, per lb	.18	36.00 per M	.16
Sal soda, per 100 lb. keg	2.15	2.25	2.75*
Roll sulphur, per 100 lb	3.60†	3.35	
Linseed oil, per gal., 5 bbl. lots	.83½	.96	.85
Lard cutting oil, 25% lard, per gal.	.55	.50	.48
Machine lubricant, medium-bodied (55 gal. metal bbl.), per gal.	.35	.35	.29
Belting—Present discounts from list in fair quantities (½ doz. rolls).			
Leather—List price, 24c. per lin. ft. per inch of width for single ply.			
Medium grade	40–5%	40–5%	40–5%
Heavy grade	30–10%	30–10%	30–10%
Rubber transmission, 6-in., 6 ply, $1.83 per lin. ft.			
First grade	50%	50–10%	50%
Second grade	50–10%	60–5%	50–10%

*In 175 lb. kegs. † Per 150 lb. lot

Comparative Warehouse Prices

New York	Unit	Current Price	Four Weeks Ago	One Year Ago
Soft steel bars	per lb.	$0.0324	$0.0324	$0.0324
Cold drawn shafting	per lb.	.04	.04	.0415
Brass rods	per lb	.1687½	.1687½	.1612½
Solder (½ and ½)	per lb.	.4012½	.4062½	.38
Cotton waste	per lb.	.13@.17½	.15@.22	15@22
Washers, cast iron (½ in.)	per 100 lb.	7.00	7.00	7.00
Emery, disks, cloth, No. 1, 6 in. dia.	per 100	3.55	3.55	3.38
Lard cutting oil	per gal.	.55	.55	.60
Machine oil	per gal.	.35	.35	.33
Belting, leather, medium	off list	40–5%	40–5%	40–2½%
Machine bolts up to 1x30 in.	off list	40%	40%	40%

MISCELLANEOUS—Continued

	New York	Cleveland	Chicago
Abrasive materials—In sheets 9x11 in., No. 1 grade, per ream of 480 sheets:			
Flint paper	$5.56	$5.84	$5.65
Emery paper	10.71	11.00	10.71
Emery cloth	29.48	31.12	29.48
Emery disks, 6 in. dia., No. 1 grade, per 100:			
Paper	1.49	1.45	1.49
Cloth	3.55	3.55	3.20
Fire clay, per 100 lb. bag		.60	.75
Coke, prompt furnace, Connellsville	per net ton		3.00@3.25
Coke, prompt foundry, Connellsville	per net ton		4.50@5.50
White lead, dry or in oil	100 lb. kegs	New York, 15.25	
Red lead, dry	100 lb. kegs	New York, 15.25	
Red lead, in oil	100 lb. kegs	New York, 16.75	

SHOP SUPPLIES

Machine bolts, ¼x1½-in., per 100, $1.70. Discount at New York warehouses on all sizes up to 1x30-in., 40%; 1½ and 1¼x3-in. up to 12-in., 15%; with cold punched hex. nuts up to 1-in. dia. (plus std. extra of 10%) 30%; with hot pressed hex. nuts up to 1x30-in. (plus std. extra of 10%) 35%.

Carriage bolts, ¼x1½-in., per 100, $1.00. Discount on all sizes up to 1x30-in., 30%.

Coach and lag screws, 1½x$\frac{7}{16}$in., $2.25 per 100, less 40%.

Tap bolts, 1½x¼-in., $1.00 per 100. List plus 35% at New York warehouses.

Bolt ends, 1x12-in., 10c. per lb., less 40%.

Nuts, semi-finished, ½x¼-in., 2c. each. Discount 70% for $\frac{5}{16}$-in and smaller and 65% for ½-in. and larger.
Case hardened ½x¼-in., 6c. each, less 50%.

Rivets, button heads, ⅜-in., ½-in., 1-in. diam. x2$\frac{1}{16}$-in. to 4½-in. $5.00* per 100 lb. at New York warehouses; cone heads same sizes, $5.20* per 100 lb. Rivets, $\frac{7}{16}$x1-in. and longer, 19c. per lb., less 50%. Same discount for tinned. EXTRA per 100 lb. for 1¼ to 2-in. long, all diameters, 25c.; ⅝-in. dia., 35c.; ¾-in. dia., 75c.; 1-in. long and shorter, 75c.; longer than 5-in., 50c.; less than 200 lb., 50c.; countersunk heads, 45c.

Washers, cast iron, ½-in., $7.00* per 100 lb. at New York warehouses; ⅝-in., $6.00* per 100 lb.

*For immediate delivery from warehouse.

Machine Requirements and Industrial Construction

Machine Tools and Equipment Wanted

Colo., Denver—Stearns Roger Mfg. Co., 1720 California St.—6 ft. radial drill and planer type milling machine.

Ind., Indianapolis — Bd. of School Commissioners, W. M. Frazer, Bus. Dir. will receive bids until April 22 for shop equipment for Washington and Thomas Jefferson high schools.

Mass., Boston—Schoolhouse Dept., F. E. Slattery, Chn., City Hall—metal working machinery for proposed addition to Boston Trade School, Roxbury.

N. Y., Binghamton—J. J. Reynolds Iron Works, Box 1006—6 ft. power brake, ¼ in. stock.

N. Y., Buffalo—Kelley Electric Machine Co., 287 Hinman Ave.—equipment including machine tools, lathes, drills, etc. for machine shop.

O., Cleveland—F. J. Opatray, 6600 Park Ave.—54 in. and 48 in. tumbling mill.

O., Cleveland—F. Roseman, 1440 East 32nd St.—2 medium size punch presses.

O., Columbus—W. E. Prindle Mfg. Co., 187 West Lakeview Ave., W. E. Prindle, Gen. Mgr.—punch press and heavy shears for cutting metals.

Wis., Milwaukee— Loeffelholz Co., 170 Clinton St.—equipment for proposed 1 story, 52 x 140 ft. addition to foundry. Estimated cost $40,000.

Wis., Milwaukee—Milwaukee Brass Specialty Co., 3200 Senator Ave.—additional machine tools including lathe, etc. for proposed 1 story, 56 x 100 ft. factory. Estimated cost $25,000.

Opportunities for Future Business

Calif., Oakland—Gantz Machine Pipe Co., c/o J. I. Gantz., 1815 East 12th St., will build a 1 story machine shop at Peralta and 22nd Sts. Estimated cost $15,000.

Calif., Richmond — Standard Sanitary Mfg. Co., 1000 Brannan St., San Francisco, manufacturers of plumbing goods, plans the construction of a 2 story, 135 x 250 ft. factory, here. Estimated cost $250,000. J. J. Donovan, Tapscott Bldg., Oakland, Archt.

Calif., San Francisco — City plans to expend $4,076,000 for railway extensions, equipment and shops.

Calif., Santa Rosa—Sophey Bros., Sebastopol, awarded contract for the construction of a 1 story auto rebuilding plant at 3rd and A Sts. here. $26,900.

Colo., Boulder—Superior Metal Products Co., Inc., H. H. Donnelley, Pres. will build a 50 x 150 ft. plant for the manufacture of steel chains for automobiles.

Ill., Cicero — Stafford Sales Co., 6301 South Park Ave., Chicago, manufacturers of automobile bumpers, has acquired a site on Fifty-ninth Ave., here and plans the construction of a plant.

Ill., Evanston — National Biscuit Co., West 15th St., New York, N. Y., awarded contract for the construction of a 3 story machine shop, etc. at Keeney and Custer Aves., here. Estimated cost $300,000.

Ind., Evansville—Standard Oil Co., 2320 Division St., is receiving bids for the construction of a garage, machine shop and warehouse. Estimated cost $200,000. Schlinz & Bailey, 53 West Jackson St., Chicago, Ill., Archts.

Ia., Des Moines — Wood Bros. Thresher Co. awarded contract for the construction of a 304 x 500 ft. manufacturing plant. Estimated cost $250,000. Noted Mar. 4.

Mass., Boston—Savoy Realty Co., c/o M. Linenthal, 333 Washington St., Engr., is receiving bids for the construction of a 2 story garage at Washington and Perry Sts. Estimated cost $250,000.

Mass., Cambridge (Boston P. O.)—National Co., W. A. Ready, Pres., 110 Brookline St., machinery manufacturers, is receiving bids for the construction of a 2 story, 45 x 95 ft. addition to factory. Estimated cost $40,000.

Mass., Everett (Boston P. O.)—R. & B. Fuel Co., 108 Bow St., will build a 1 story, 70 x 80 ft. repair garage. Estimated cost $40,000. Schein & Levine, 448 Broadway, Chelsea, Archts.

Mass., Framingham — Guerney Heater Mfg. Co., Arlington St., awarded contract for the construction of a foundry, etc. Estimated cost to exceed $40,000.

Mass., Lexington—J. C. Phelps, 43 Percy St., is receiving bids for the construction of a 1 story, 80 x 100 ft. repair and service garage at 33 Bedford St. Estimated cost $80,000. W. Littlefield, 9 Hamilton Place, Boston, Archt.

Mass., Medfield—C. C. Pierce, is receiving bids for the construction of a 1 story, 80 x 120 ft. repair and service garage. Estimated cost $45,000. R. M. Stowell, 184 Boylston St., Boston, Archt.

Mass., Somerville (Boston P. O.)—Winter Hill Realty Co. Inc., 383 Broadway, is receiving bids for the construction of a 2 story repair and service garage on Bond St. Estimated cost $100,000. S. H. Watkins, 164 Federal St., Boston, Archt. Noted Dec. 24.

Mass., Watertown (Boston P. O.)—American Soda Fountain Co., Congress St., Boston, awarded contract for the construction of a 1 and 2 story, 175 x 300 ft. manufacturing plant on Walnut St. Estimated cost to exceed $40,000. Noted Feb. 25.

Mo., St. Louis—Missouri Engine Co., 2804 North 11th St., awarded contract for the construction of a 1 and 2 story, 126 x 145 ft. factory at 3300 North Broadway. Estimated cost $75,000.

N. J., Belleville—G. C. Bergen, Purch. Agt. will soon award contract for the construction of a carpenter and machine shop for Hospital for Contagious Diseases. Estimated cost $30,000. R. W. Erler, 45 Clinton St., Newark, Archt.

N. J., Bloomfield — American LaFrance Fire Engine Co., 67 Brookside Place, awarded contract for the construction of a 1 story factory. Estimated cost $50,000.

N. J., Harrison (Newark P. O.) Otis Elevator Co. Inc., 17 East 42nd St., New York, N. Y., awarded contract for the construction of a 1 story, 80 x 100 ft. car shop here.

N. J., Trenton—City Commission, will soon receive bids for the construction of a 3 and 5 story fire headquarters and machine shop on Perry St. Estimated cost $385,000. J. O. Hunt, 219 East Hanover St., Archt.

N. Y., New York—Andrea Holding Corp., Walton and Mott Aves., awarded contract for the construction of a 3 story, 158 x 225, 89 x 100 and 80 x 140 ft. radio manufacturing plant.

N. Y., Portland Point—Pennsylvania Cement Co., 131 East 46th St., New York, awarded contract for the construction of a machine shop, etc. here. Estimated cost $300,000.

N. Y., Rochester — Stromberg-Carlson, 1050 University Ave., is having plans prepared for the construction of a 1 story, 160 x 460 ft. factory on Blossom Road. Estimated cost $300,000 J. F. Warner, Granite Bldg., Archt. S. Firestone, 59 South Ave., Engr.

N. Y., White Plains—International Motor Truck Co., 25 Broadway, New York, will soon receive bids for the construction of a repair and service garage on Kensico Ave. here. Estimated cost $200,000. E. E. Sellye, 101 Park Ave., New York, Archt.

O., Cincinnati—Formica Insulation Co., 4614 Spring Grove Ave., awarded contract for the construction of a 2 story, 80 x 100 ft. addition to automobile manufacturing plant. Estimated cost $40,000.

O., Cincinnati—Steinkoenig Motor Truck Co., 2311 Harrison Ave., awarded contract for the construction of a 2 story, 90 x 150 ft. plant. Estimated cost $65,000.

O., Cleveland—Empire Phone Parts Co., c/o W. J. McNamara, 2261 East 14th St., awarded contract for the construction of a 2 story, 61 x 110 ft. factory at 10316 Madison Ave. Estimated cost $50,000.

O., Cleveland—Bohnard & Parsson, 1900 Euclid Bldg., Archts., is receiving bids for the construction of a 2 story, 52 x 165 ft. factory at 14025 Aspinwall Ave. for The Lindsay Wire Weaving Co., H. L. Lindsay, Pres. Estimated cost $75,000. Noted April 1.

O., Warren—Aetna Foundry & Machine Co. plans the construction of addition to foundry to double the capacity. Estimated cost $100,000.

Pa., Allentown—W. E. Erdell, 601 North 6th St., is receiving bids for the construction of a 4 story 84 x 140 ft. garage on North 5th St. Estimated cost $150,000. J. E. Everett, Archt.

Pa., Allentown—Jacoby & Everett, Commonwealth Bldg., Philadelphia, Archts., will receive bids until April 10 for the construction of a 4 story, 83 x 141 ft. garage at 28-34 North 5th St. for Central Motor Ramp Garage Co. Estimated cost $175,000.

Pa., Philadelphia—Edward Pausser, will soon award contract for the construction of a 2 story, 46 x 100 ft. machine shop at 738 South 42nd St. Estimated cost $12,000. W. E. S. Dyer, Land Title Bldg., Engr.

Pa., Phillipsburg—Ingersoll-Rand Co., 11 Broadway, New York, N. Y., awarded contract for the construction of addition to plant, here. Estimated cost $50,000.

R. I., Pawtucket—Davis-Jones Insulated Wire Co., D. S. Davis, Pres. and Treas., awarded contract for the construction of a 2 story plant.

Tenn., Nashville—Federal Can Co., 500 Benton Ave., awarded contract for the construction of a 1 story addition to factory. Estimated cost $50,000.

Tex., Corpus Christi—Demountable Batteries Co., Dayton, O., plans the construction of a manufacturing plant, here. Private plans.

Tex., Cleburne—Gulf, Colorado & Santa Fe Ry. Co., 408 Union Depot Bldg., Galveston, awarded contract for the construction of a 122 x 517 ft. blacksmith shop and 45 x 228 ft. flue shop, etc. here. Estimated cost $500,000. F. Merritt, Ch. Engr. Noted Mar. 11.

Wis., Milwaukee—W. J. Kozick, 664 26th St., Archt., is receiving bids for the construction of a 3 story, 32 x 100 ft. manufacturing plant for Ruesch Printing Machinery Co., 485 Broadway. Estimated cost $50,000. Noted Mar. 4.

Wis., Platteville—F. Russell, is having plans prepared for the construction of a 40 x 110 ft. machine shop and 20 x 30 ft. office. H. Kleinhammer, Archt.

Wis., West Allis—Fulton Co., 732 75th Ave., awarded contract for the construction of a 1 story, 60 x 180 ft. addition to machine shop. Estimated cost $40,000.

Ont., Toronto — Moore & Hughes, 577 Yonge St., awarded contract for the construction of a 2 story, 130 x 260 ft. garage and show room at Bay and St. Joseph Sts. Estimated cost $200,000.